THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. XII.—DECEMBER, 1907.

ORIGINAL ARTICLES.

I.—The Structure of Glacier Ice.

By R. M. Deeley, M.I.C.E., F.G.S.

(PLATES XXIII AND XXIV.)

IN the Geological Magazine for April, 1895, p. 152, the results of some observations made by Mr. George Fletcher, F.G.S., and myself on the structure of glacier ice were given.

Thin plates of ice were made by cutting and melting, and then examined in polarized light. In all cases it was found that the individual crystals were in close contact, there being no evidence of the presence of a cutectic separating them. The crystals in the same piece varied very greatly in size, and had very irregular outlines.

As the sections which we figured were in all cases drawn by hand, I thought it advisable to construct a special form of instrument with which to obtain actual photographs of thin sections of glacier ice. The instrument eventually used consisted of two bundles of thin glass plates, one being used as a polarizer and the other as an analyser. They were fixed vertically above each other, and between them was the glass stage upon which the thin ice sections rested. Below the analyser was a small lens throwing the image of the ice section upon a photographic plate.

Last Summer, accompanied by Mr. H. Arnold-Bemrose, M.A., F.G.S., who kindly assisted me in the matter, I visited the Furka Pass, and we obtained photographs of the ice of the Rhône Glacier.

Figs. 1 and 2 are full-sized photographs of thin slices of ice. Samples with small crystals were selected, so as to bring many crystals within the limits of the field. The ice section was about ·03 inch thick, and where the surface between two crystals is at an angle with the glass plate upon which the ice section rested, interference fringes are consequently to be seen.

In the ice caves we noticed the beautifully lined surfaces of the crystals of which the glacier is formed, and were successful, by adopting very simple means, in obtaining correct reproductions of the structure. The lines consist of alternate ridges and furrows, and we found that by placing a piece of paper upon the ice surface and rubbing with a pencil, very beautiful copies could be obtained. Figs. 3 to 7 are reproductions of these.

The structure on the glacier ice surface shown by these rubbings results from the slow melting and evaporation of the surface; for if by the warm hand or other means the surface be melted until it is quite smooth, in the course of a few hours the structure will again develop. Melting takes place most actively between the crystals, forming comparatively wide channels, shown in the rubbings by the broad white lines. The small white dots are air bubbles.

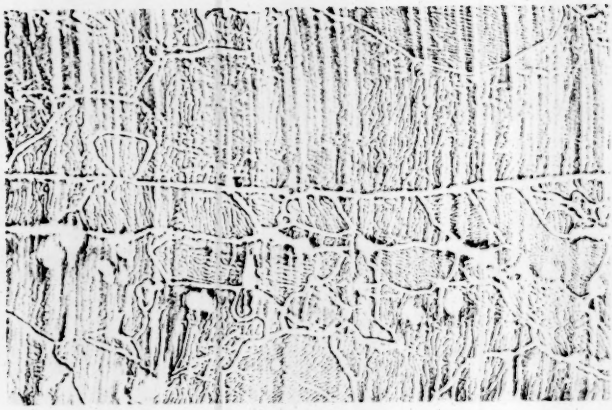
In Fig. 3 the crystalline grains vary largely in size and have very irregular outlines. The markings on their surfaces much resemble 'finger-prints,' and the lines run at various angles. In Fig. 4 two main lines of fracture run parallel with each other across the ice. They are not quite straight, the boundaries of the individual grains having moved somewhat owing to the growth of some grains at the expense of others, since shear took place. One line of shear in Fig. 5, though somewhat bent, is almost unaffected by this; but in Figs. 6 and 7 marked changes have taken place in what were originally straight lines of shear. It will be noticed that the coarseness of the ridges and furrows on the surfaces of the grains varies very much. This is probably due to the angle the optic axis bears to the lined surface.

McConnell[1] and O. Mügge[2] have shown that an ice crystal behaves as if it consisted of an infinite number of very thin, non-expansible, but perfectly flexible layers, somewhat like paper, between the different sheets of which there is a sticky substance, so that the sheets can only with difficulty glide over each other. The layers, being non-expansible and perpendicular to the optic axis, in the act of bending slide over each other; but the crystal axes still remain at all points perpendicular to the bent surface. Mügge states that the slipping or sliding did not commence in the case he tried until the stress reached a certain limit, but it does not appear that the experiment was quite decisive on this point, as the ice used was probably not quite homogeneous. Whether the ice is plastic or viscous at right angles to the optic axis is therefore uncertain.

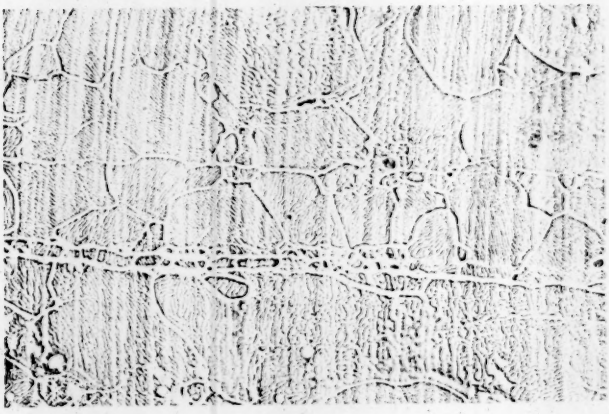
Striations on ice crystals were noticed by Mügge. He states that broken surfaces of ice, especially those of bent bars, almost always show a fine striation at right angles to the optic axis; but is unable to state whether the striations observed on glacier grains run parallel to the base and are identical with the striation of translation. I have never seen these striations except on strained ice, and although proof that the striations on glacier grains run parallel to the base is required, I am strongly inclined to think that they do, and that they develop on such surfaces by evaporation owing to the irregular stresses in the crystals. If this view should prove correct, the irregularities in the striations shown on the ice rubbings indicate to us the direction of the optic axis and show that what may be regarded as large crystals are by no means symmetrical.

The greater portion of the ice of a glacier has the structure shown in Fig. 3. Here the grains are quite irregular, large ones and small

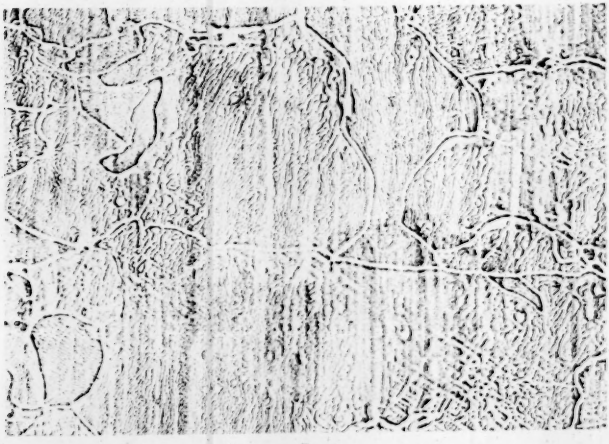
[1] Proc. Roy. Soc., 1890, pp. 48, 259, and 1891, pp. 49, 323.
[2] Jahrb. für Min., 1895, p. 211.



5



6



7

Figs. 5-7. Reproductions of actual surface-markings on ice in glacier ice caves, consisting of ridges and furrows.

ones lying side by side. Shear planes are, however, constantly forming and breaking up, and displacing the parts of the crystals more or less. Figs. 4, 5, and 6 show this clearly. As, however, the ice grains are continually changing shape, some growing and others decreasing in size, these shear planes in time disappear as they have partly done in Fig. 7.

In the paper already referred to this interchange of molecules, which causes some glacier grains to grow and others to decrease, was regarded as the cause of glacier motion, and should produce true viscous motion in the glacier as a whole, even though it may be unsound to regard an ice crystal as truly viscous at right angles to the optic axis.

EXPLANATION OF PLATES XXIII AND XXIV.

Figs. 1–2. Full-sized photographs of thin slices of ice, about 0·03 inch thick.
,, 3–7. Lines and surface-markings obtained by taking rubbings of the actual surfaces of the glacier ice in ice-caves. They consist of alternate ridges and furrows.

II.—The Relationships of the 'Sparassodonta.'[1]

By Dr. W. D. Matthew, of the American Museum of Natural History, New York.

THE Sparassodonta are an interesting group of extinct mammals found in the Tertiary formations of Patagonia. They appear to have taken the place of true Carnivora in South America during most of the Tertiary period, as the Carnivorous Marsupials do in the modern fauna of Australia. Their relationship has been in dispute since they were first made known to science by the distinguished South American palæontologist Florentino Ameghino. In dental formula and other characters of the teeth and jaws they agree with the Carnivorous Marsupials, and show a high degree of adaptive specialization for predaceous habits. Dr. Ameghino was able to determine, however, from specimens in his collection, that the replacement of the premolars, in certain genera at least, was more complete than in modern marsupials, and approached that of the placental carnivora. He regarded them, therefore, as an intermediate group, ancestral to the Creodonta and modern Carnivora. Mr. Tomes, in his interesting study of the enamel structure of the Creodonta and allied groups, has recently shown that in one genus of Sparassodonts the enamel shows the more highly differentiated structure of the true Carnivora, instead of the more primitive structure of Marsupial Carnivores. The collections made by the Princeton and American Museums in the Santa Cruz formation of Patagonia contain a splendid series of Sparassodont remains, including skulls and skeletons of the principal genera, which have recently been exhaustively studied by Dr. Sinclair. These show that the Sparassodonts agree with Marsupials, and especially with *Thylacinus* in almost all the distinctive features of dentition, skull, and skeleton characters by which they are separated from the placental mammals. Mr. Sinclair gives an extended list of the marsupial

[1] "Marsupials or Creodonts?" R. L. in *Nature*, March 21st, 1907. C. S. Tomes, "On the Minute Structure of the Teeth of Creodonta, etc.": Proc. Zool. Soc. London, June, 1906. W. J. Sinclair, "Marsupialia of the Santa Cruz Beds": Reports of the Princeton Expeditions to Patagonia, vol. iv, part 3, Sept., 1906.

characters of the group, embracing twenty or thirty more or less independent points of structure, and including most of the important osteological peculiarities of modern Marsupials. There are, however, certain points of difference.

1. Sinclair's material did not enable him to demonstrate any more extensive replacement of the premolars than prevails among modern Marsupials, viz. p. 4 only. Ameghino states that in *Borhyæna* the canine and in *Cladosictis* the canine and second premolar are also preceded by milk-teeth.

2. Palatine vacuities, characteristic of most Marsupials, as well as some placental mammals, are lacking in this group.

3. There are no indications of marsupial bones. This does not necessarily mean that they were absent; they may have been small and without distinct articular facets, and not preserved in the fossil skeleton. They are vestigial in *Thylacinus*.

4. Enamel structure as in Placental Carnivora. This is known only in one genus, *Borhyæna*, the largest and most specialized of the group. Mr. Tomes' paper was not published at the time Dr. Sinclair's monograph was written, so that this important point was unknown to him.

On the other hand, we have—

1. Dental formula typically marsupial, with three premolars and four true molars, as opposed to the placental formula with four premolars and three true molars.

2. The characters of the basicranial region agree with Marsupials, in some respects also with Insectivores, and differ from Creodonts and modern Carnivores.

3. The malar bar is extended posteriorly to take part in the preglenoid process.

4. The posterior border of the palate is perforated by a large foramen on either side of the posterior nares.

5. Post-zygomatic and sub-squamosal foramina present.

6. Transverse process of seventh cervical vertebra perforated by vertebral artery.

7. The arrangement of carpals and tarsals is in fairly close agreement with Carnivorous Marsupials, and decidedly different from the type common to Creodonts and the less specialized Carnivora. In particular, the small lunar and large magnum, the peculiar type of astragalus, etc., agree with Marsupials generally and differ from Placentals generally, the agreement and difference being very marked when comparison is confined to Carnivorous Marsupials and Placentals.

Various other characters are listed by Dr. Sinclair, but the above appear to be the most essential. In the writer's opinion any one of these outweighs in importance all of the characters except the last, in which the Sparassodonts differ from Marsupials. The enamel structure is doubtless a character of high importance if constant throughout the group, but even if it proves to be so it admits of an explanation which would bring it in accord with the marsupial relationships of the group.

Dr. Lydekker is not convinced by the evidence adduced by Sinclair. He regards the Sparassodonts as descended from Creodonts.

Concerning the dental formula he observes: "The dental formula of the cheek-teeth, in the opinion of Dr. J. L. Wortman and the present writer, is identical in the Sparassodonts, Carnivorous Marsupials, and Creodonts, and is therefore of no importance except to indicate the mutual relationship of all three groups." This assertion can only be taken to mean that the dental formula in Marsupials and Sparassodonts is *derived* from that of Creodonts by reduction of the successional premolars. This theory is very generally held. But for 'Creodonts' might just as well have been substituted Carnivora or Eutheria in general. Accepting Dr. Lydekker's view as to the derivation of one formula from the other, the fact remains that they *are* distinct and show no approximation among the oldest known Tertiary representatives of the two groups. Carnivorous Marsupials, perfectly typical as to dental formula, inflection of the jaw, etc., occur with the early Creodonts in the Eocene and Oligocene formations of North America and in the Oligocene of Europe. Indeed, if we may rely on the imperfectly known Jurassic mammals the distinction between the two formulas dates well back into the Mesozoic.

In one or more genera of the Sparassodonta, Dr. Ameghino has found evidence that the canines and the second post-canine tooth (premolar), as well as the third, is replaced by a successional tooth. In others, so far as known, the third premolar only is replaced, as in modern Marsupials. This does not affect the dental formula. The fourth post-canine tooth is always molariform, belongs to the lacteal series, and is never replaced by a successional tooth. In no Creodont is any tendency observed toward the retention of the fourth milk premolar in the permanent series; the number of permanent molars does not exceed three, and the replacement is of the normal Eutherian type.

The absence of palatal vacuities among the Santa Cruz Sparassodonta and of epipubic bones in one genus cannot be considered as of equal importance with the dental formula and other characters listed above, since they are neither constantly nor exclusively present among Marsupials. Epipubic bones are vestigial in *Thylacinus*, the most nearly related form among modern Marsupials; their presence in less specialized types of ancient and modern Marsupials indicates them as a primitive character of the order lost in certain specialized races. Even if this character were known to be constant throughout the Sparassodonta it would merely accord with the general trend of their specialization, and is surely no argument for removing them from the Marsupialia. As for the absence of palatine vacuities in Sparassodonts, this feature can hardly be given great weight since palatal vacuities are absent in several modern Marsupials and present in several Insectivores. Whether the vacuities are primary or secondary is not very clear; it does not follow, at all events, that because the Sparassodonts are related to *Thylacinus* they are directly ancestral, and the presence of palatine vacuities in the modern genus may be an archaic character lost by the South American group but retained along with several other more primitive characters by the modern Australian genus. Palatal vacuities are absent in the primitive Erinaceid *Proterix* and in the Leptictidæ, from which family the hedgehogs are probably derivable, but are present in the modern hedgehog; this may be

a parallel case. The facial vacuities of the Artiodactyla are certainly secondary developments and are independently developed in different families. The hypothesis that they are retained from reptilian ancestry is certainly not supported by any adequate evidence. Nevertheless, the palatal vacuities of Marsupials may date back to the earliest differentiation of the order, and their loss be an independent specialization in each group where it occurs; the uniform presence of the character in all the more generalized members of the order seems to point to this conclusion.

The principal marsupial characters of the Sparassodonta thus appear to be of much greater weight than anything that can be adduced in favour of their placental relationship. They are definite, constant, and exclusive characters of the marsupial skeleton, and no material approximation to any of them occurs among the Creodonts.[1] There is but one character of real importance which appears to connect the Sparassodonts with the Creodonts and modern Carnivora, viz. the histological structure of the enamel. The investigations of Mr. Tomes on the enamel structure in Marsupials, Creodonts, and Carnivora have yielded some very significant results, and it may be as well to summarize them briefly and point out what their real bearing is. He shows that—

1. The marsupial enamel is distinguished by two principal characters: (*a*) it is penetrated by tubes from the dentine, and is thus less completely differentiated; (*b*) its component prisms are parallel, lacking the interlacing arrangement of Carnivora.

2. In the Inadaptive Creodonts (*Sinopa* and *Hyænodon*, family Hyænodontidæ; *Oxyæna*, family Oxyænidæ; *Pachyæna* and *Mesonyx*, family Mesonychidæ) the enamel structure is identical with that of modern Carnivora.

3. In the Adaptive Creodont *Didymictis* and the primitive Cynoid *Cynodictis* the enamel is not penetrated by tubes from the dentine, but its component prisms are parallel.

4. In *Borhyæna* among the Sparassodonta the enamel structure is that of Inadaptive Creodonts and modern Carnivora.

5. Traces of the more primitive enamel structure are seen in the lower orders of Placentals (Insectivora and Rodents); and in *Hyrax*, the most primitive of hoofed Placentals, the enamel is like that of Marsupials.

6. Among the Marsupials, the more specialized carnivorous types exhibit the nearest approximation to the higher development of the enamel characteristic of Placentals. *Phascolomys* alone among the Diprotodonta resembles the Placentals in its enamel structure.

From these facts we may deduce that—

1. The Marsupials are not derivable from the Creodonta, since their enamel structure is much more primitive.

2. The Creodonta are closely related to the Fissipede Carnivora, and, like them, show a high grade of evolution in enamel structure.

[1] There is a slight inflection of the jaw in the later Mesonychidæ, but it is not at all like the marsupial inflection. Certain other alleged approximations are equally slight, superficial, or unimportant.

3. The Adaptive Creodonts are more primitive than the Fissipedia, while the Inadaptive Creodonts have reached an equal grade of specialization in enamel structure as in other respects.

4. *Borhyæna* is more highly developed than any modern marsupials, equalling the modern Carnivora in its enamel specialization. Whether this applies to the other Sparassodonta with less specialized dentition is not known.

The above conclusions harmonize very readily with the evidence from the morphology of the teeth, skull, and skeleton in the Carnivorous Marsupials, Creodonts, and modern Carnivora. They are certainly not in accord with Dr. Lydekker's view that the Marsupials are derived from Creodonts. The highly developed enamel structure of *Borhyæna* may be best interpreted as meaning that certain of the South American pseudo-Carnivora were more progressive and specialized in the histology of their teeth than any of the modern Australian pseudo-Carnivora, as they certainly are in many other features of their osteology and dental evolution, in each case paralleling (for obvious mechanical reasons) the Placental Carnivora. The loss of epipubic bones and of palatal vacuities might also be expected as a consequence of their more progressive character, while their marsupial derivation and relationship is attested by practically all the remaining characters distinctive of the order.

As regards the position of the Creodonts, the writer has had the opportunity during the last three years of studying a collection far more extensive and complete than has ever been known before, and hopes shortly to publish the results of these studies. It is sufficient to say at present that the evidence is entirely in accord with the conclusions derivable from the valuable data on the histology of the teeth given by Mr. Tomes; that the Creodonts were nearly related to the modern Carnivora, and show no considerable approach to the Marsupials; that the Inadaptive Creodonts (Creodonta of Wortman and Lydekker) are not intermediate between Carnivora and Marsupials, but parallel the modern Carnivora, specializing earlier than the Adaptive group (included in Carnivora by Wortman), which latter approximates the Marsupials to a limited extent by retention of several primitive characters. These conclusions have been maintained in recent years, and the antiquity of the division between Marsupials and Placentals emphasized especially by Osborn, Scott, and the writer in this country, and by most European authorities; the additional evidence confirms them throughout.

III.—Sedgwick Museum Notes.

The Base of the Silurian near Haverfordwest.

By F. R. Cowper Reed, M.A., F.G.S.

ON several previous occasions[1] the author has described in the pages of the Geological Magazine certain fossils from so-called "Slade Beds" from the roadside near St. Martin's Cemetery, Haverfordwest.

[1] Reed: Geol. Mag., Dec. V, Vol. II, 1905, pp. 98, 100, 103, Pl. IV, Figs. 8–12; ibid., pp. 447, 448, 449, 451, 453, Pl. XXIII, Figs. 3, 4–7, 9, 16; ibid., pp. 493, 494, 497, 498, 500, Pl. XXIV, Figs. 1–10, 14, 15; ibid., Vol. III, 1906, p. 361.

A large collection of fossils has been made by Mr. V. M. Turnbull from this particular locality during the last few years and presented to the Sedgwick Museum. From a prolonged study of this material and comparison with the typical fauna of the Slade Beds as described by Messrs. Marr & Roberts, the conclusion has been forced upon me that we have here to deal with a higher palæontological horizon than the true Upper Bala of this district, and that there is much more reason for putting it in the Silurian than for keeping it in the Ordovician. The stratigraphical evidence which has subsequently become available is in support of this view. A list of the fossils from this bed may be useful at the present moment, particularly as the Sedgwick Museum possesses by far the most extensive series which has been collected from it (see opposite page, 537).

The rock in which they occur is a greenish-grey, fine-grained, argillaceous mudstone with occasionally minute specks of mica and a little arenaceous material, but usually of a very uniform smooth texture. It breaks in an irregular, often subconchoidal manner, and is devoid of any regular or well-marked planes of division. Exposed surfaces and the fossils themselves are generally more or less iron-stained. In appearance and general characters it is difficult or impossible to distinguish the rock from the higher beds of the Slade Series, but the fauna is completely different.

The mudstone lies above a series of unfossiliferous (?) black shales, and intercalated in the latter is found a persistent bed of sandstone or grit. This whole series of beds may be conveniently termed the "St. Martin's Beds," as a local designation seems necessary; and the fossiliferous mudstone in it may bear the name of the "St. Martin's Mudstone."

The true Ordovician occurs near Portfield House as a more micaceous mudstone lying fifty yards below the band of sandstone, according to Mr. Turnbull, and yielding *Trinucleus seticornis*, *Orthis biforata*, *Leptæna sericea*, etc. But until the whole succession has been worked out we may defer attempts at correlation, and a detailed comparison of the St. Martin's and associated beds with those of other areas is at present undesirable.

The occurrence of *Phacops mucronatus*, *Strophomena silurianа*, *Meristella* cf. *crassa*, and *Diplo.* cf. *modestus* are sufficient in themselves to show that we have here to deal, not with the highest Ashgillian, but with the base of the Silurian. The strongly marked palæontological break between the St. Martin's Mudstone and the Slade Beds proper seems abundantly to justify the drawing of the Silurian line below and not above them. All the typical Slade species are absent; no *Trinucleus* occurs, and the higher affinities of the fauna are indicated by the occurrence of certain species (*Cornulites scalariformis*, *Goniophora* cf. *cymbæformis*, *Meristella* cf. *crassa*, *Atrypa* cf. *flexuosa*, *Orthis* cf. *Edgelliana*, *Scenidium Lewisi*, *Crania Grayi* var., *Lingula Symondsi*, *Diplo.* cf. *modestus*) which are not known from undoubted Ordovician beds. The Llandovery Beds of the Gas Works have, on the other hand, a completely distinct fauna.

With the exception of the Brachiopods (especially the genus *Orthis*) the fauna of the St. Martin's Mudstone is poor; the Gasteropods,

Cephalopods, and Graptolites are very rare, the two latter groups being represented only by two or three specimens in the whole collection. Lamellibranchs are numerous in peculiar species, but not in individuals. Trilobites are not common, but of them *Acidaspis* and *Phacops* occur most frequently.

[*Note.*—In the sequence given by Mr. Cantrill, his Beds 1, 2, 3, and 4 correspond to my "St. Martin's Beds"; see p. 538.]

LIST OF FOSSILS FROM THE ST. MARTIN'S MUDSTONE.

Phacops mucronatus, Brong.
Ph. sp.
Cyphaspis megalops, McCoy.
Acidaspis sladensis, Reed.
A. sp.
Lichas (*Corydocephalus*) sp.
L. cf. *laciniatus*, Dalm.?
Turrilepas sp.
Cornulites scalariformis, Vine.
Tentaculites sp.
Orthoceras cf. *gracile*, Portl.
Bellerophon cf. *acutus*, Sow.
Cyrtolites sp.
Hyolithes sp.
Pleurotomaria (*Clathrospira*) sp.
P. (*Liospira*) sp.
Holopella sp.
Modiolopsis Martini, Reed.
M. subgradata, Reed.
M. 2 sp. ind.
Whitella (?) *inutilis*, Reed.
Orthodesma semiradiata, Reed.
Goniophora cf. *cymbæformis*, Sow.
Arca Turnbulli, Reed.
Ctenodonta sladensis, Reed.
C. linguatis, Phill.
C. sp.
Meristella cf. *crassa*, Sow.
Atrypa imbricata, Sow. (cf. *flexuosa*, Marr & Nicholson).
Orthis elegantula, var.
O. cf. *Edgelliana*, Salt.
O. porcata, McCoy, var. *sladensis*, Reed.
O. vespertilio, Sow., var.?
O. aff. *Bouchardi*, Dav.
O. sp. ind.
Strophomena siluriana, Dav.
S. siluriana, var.
S. sp.
Leptæna rhomboidalis, Wilck.
Scenidium Lewisi, Dav.
Crania Grayi, Dav., var.
Orbiculoidea perrugata, McCoy.
Lingula Symondsi, Sow.
L. ovata, McCoy?
L. 2 sp. ind.
A new Cystidean.
Crinoid stem-joints.
'*Favosites*' *fibrosus*, Goldf.
Diplograptus cf. *modestus*, Lapw. (determined by Miss Elles).

IV.—Stratigraphical Note.[1]

By T. C. Cantrill, B.Sc. Lond., of the Geological Survey.

THE fossils which Mr. V. M. Turnbull has collected from supposed Slade Beds on the "roadside near St. Martin's Cemetery, Haverfordwest," were obtained along the north side of a road leading westward from St. Martin's Cemetery to Portfield House, on the west side of the town. About half-way between the Cemetery and Portfield House the road is crossed by a by-road known as Jury Lane; one of the fossiliferous localities lies 110 yards east of Jury Lane crossing, another is 100 to 150 yards west of it. The area in question is contained in the Old Series one-inch Geological Survey map, Sheet 40, the New Series one-inch map, Sheet 228, and in the six-inch map, Pembrokeshire, Sheet 27 N.E.

So long ago as 1885 Messrs. Marr & Roberts[2] worked out the general structure of the district, and showed that the town of

[1] Communicated by permission of the Director of H.M. Geological Survey.
[2] "The Lower Palæozoic Rocks of the Neighbourhood of Haverfordwest": Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476–491.

Haverfordwest is situated on or near the junction of the Lower Llandovery Beds on the south with the Slade Beds of the local Upper Bala on the north. But without a complete and detailed survey of the ground it would have been hazardous to assign definitely any given locality in the neighbourhood of the junction to either Bala or Llandovery. Messrs. Marr & Roberts showed that at or near the base of the Llandovery there is a band of coarse conglomerate, succeeded by a grit; the former locally thins out altogether; the latter is less variable. The grit was described by them as exposed in a railway-cutting south of Shoalshook (north-east of Haverfordwest), but was not traced by them farther westward, into the immediate locality which has since yielded fossils to Mr. Turnbull.

The recent work—as yet unpublished—of the Geological Survey at Haverfordwest has enabled us to arrive at the following sequence:—

Lower Llandovery (part).	5.	Green mudstones, fossiliferous, with thin grits and a group of sandstones. Haverfordwest gasworks.
	4.	Green mudstones, softer and more shaly than 5, and comparatively barren. Railway-cuttings north-east of Haverfordwest Station.
	3.	Shales, dark-grey and blue-black.
	2.	Sandstone. North-east end of railway-cutting at Cethings.
	1.	Shales, dark-grey and blue-black, with conglomerate sometimes present within them or at their base.
Slade Beds (Bala).		Fossiliferous mudstones.

The sandstone (No. 2) is the grit described by Messrs. Marr & Roberts as met with "in the railway-cutting south of Sholeshook" (op. cit., p. 484). To their description we are now able to add that from the railway the sandstone can be traced westward to St. Martin's Cemetery, which it traverses from end to end, and thence through the fields bounding the north side of the road which yielded Mr. Turnbull's fossils. As the beds dip steeply southward it follows that the fossil-bed in question is in the Llandovery and not in the Slade. A Brachiopod band a foot or so thick is present in the railway-cutting at Cethings at 30 feet above the top of the sandstone (No. 2 of table); it occurs at the junction of the dark shales (No. 3) with the overlying mudstones (No. 4), which for some feet above the junction are characterized by small dark blotches. Exactly the same sequence obtains at the fossiliferous localities discovered by Mr. Turnbull west of St. Martin's Cemetery: the sandstone yields débris in the hedges, and is followed on the south by black shales; these pass up where they reach the north side of the road into dark-green mudstones, which yielded the fossils, while the blotched mudstones are exposed on the south side of the road close by. The beds strike along the road, so that all the fossils are referable to approximately one and the same horizon, which I estimate to lie about 250 feet above the base of the Lower Llandovery.

Perhaps one of the most interesting fossils Mr. Turnbull has obtained from the St. Martin's Cemetery localities is a graptolite which Miss G. L. Elles identifies as *Diplograptus modestus*, a characteristic Lower Birkhill form common in the *Diplograptus vesiculosus* zone in the Moffat district of Scotland.

V.—Further Notes on the Arthropoda of the British Coal-measures.

By Henry Woodward, LL.D., F.R.S., F.G.S.

FOR some years past a Committee of Littleborough and Rochdale geologists, consisting of Messrs. W. H. Sutcliffe, Walter Baldwin, W. A. Parker, S. S. Platt, and others, have devoted themselves to the task of working out the beds of shale containing clay-ironstone nodules, a portion of the Middle Coal-measures at Sparth Bottoms, half a mile south-west of Rochdale Town Hall, in beds estimated to occur 135 feet above the Royley Mine Coal-seam.

In the clay-ironstone nodules occur well-preserved ferns, *Calamites*, *Sigillariæ*, shells of *Carbonicola acuta* and other Coal-measure lamellibranchs, whilst the number of Arthropoda obtained is probably unsurpassed in any locality of this formation.[1]

The first Arthropod obtained from Sparth Bottoms was noticed by Mr. Walter Baldwin, F.G.S., under the name of *Prestwichia rotundata*, Prestw., sp. (Trans. Manch. Geol. Soc., vol. xxvii, part 6, 1901, pp. 149–155, with a plate); the second in 1903, by the same geologist, who identified it as *Bellinurus bellulus*, König (op. cit., vol. xxviii, part 8, pp. 198–202). The third and most important discovery was made by Mr. W. A. Parker, F.G.S., namely, a new species of fossil Scorpion, which was described and figured in 1904 by Messrs. Baldwin & Sutcliffe under the name of *Eoscorpius Sparthensis* (Quart. Journ. Geol. Soc., vol. lx, p. 396, fig. 2). These geologists have continued their researches, of which a brief account was given by me at the York Meeting of the British Association (1906). Many subsequent finds have been most obligingly confided to me by these gentlemen, and through the kindness of Mr. W. H. Sutcliffe the specimens figured have since been presented to the Geological Department of the British Museum (Natural History), the only condition imposed being that they should be described. I am endeavouring gradually to carry out this part of the agreement.

Previously (Geol. Mag., 1905, Dec. V, Vol. II, pp. 433–444) I had described and figured various forms, namely: *Anthrapalæmon serratus*, H. Woodw., sp. nov. (op. cit., pp. 438–439, Figs. 1, 2); *Euphoberia Brownii*, H. Woodw. (Fig. 3); and *Xylobius moniliformis*, H. Woodw., sp. nov. (op. cit., pp. 442–443, Fig. 4). In that paper I also gave a summary of several other Arthropods discovered and described from the Lancashire Coal-measures up to that date (1905).

In June last I figured and described two new species of *Eurypterus* from the Coal-measures of Derbyshire[2] (Geol. Mag., 1907, pp. 277–282, Pl. XIII); and in September I gave a description of the brood-plates, or marsupium, lately discovered in several examples (evidently the females) of *Pygocephalus*, a primitive Schizopod Crustacean (op. cit., 1907, pp. 400–407, Pl. XVIII), which was first obtained in 1857 from the Glasgow Coalfield, afterwards from near Manchester, later from Dudley,[3] and finally from Sparth, Rochdale.

[1] Abstract British Association Reports, York Meeting, 1906, Section C (Geology).
[2] Discovered by Dr. L. Moysey, M.A., of Nottingham.
[3] Discovered by Mr. Herbert W. Hughes, Assoc. R.S.M., F.G.S., of Dudley.

1. Bellinurus Baldwini, sp. nov.

Amongst other interesting fossils from this last-named locality is a small king-crab which I believe to be new and undescribed; the following brief description may serve for its identification.

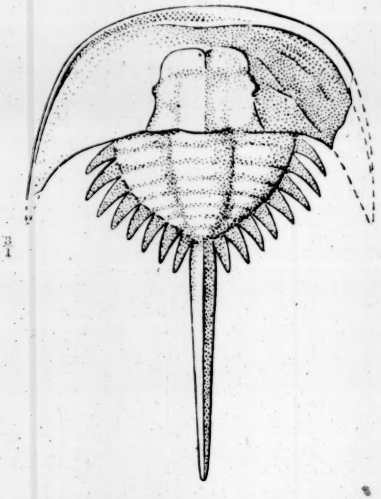


Fig. 1.—*Bellinurus Baldwini*, H. Woodw., sp. nov. Enlarged three times nat. size. Coal-measures: Sparth Bottoms, Sparth, near Rochdale. Presented by Mr. W. H. Sutcliffe, F.G.S., to the Geological Department of the British Museum (Natural History).

This small and nearly perfect king-crab has a widely expanded semicircular head-shield (prosoma), $2\frac{1}{2}$ times as broad as it is deep, the genal or lateral portions of the shield being each as broad as the central portion (glabella); the lateral angles of the head-shield are produced posteriorly into stout, well-developed genal spines, the points of which extend as far back as the sixth post-cephalic segment of the opisthosoma. The head-shield, or prosoma, is depressed or flattened anteriorly, and has a broad, well-defined margin, widest in front, diminishing in breadth laterally, till it ends in the extremity of the cheek-spines. A clearly-defined raised line separates the glabella from the genal portions, but the cheeks are confluent in front of the glabella, which is enclosed by a raised line forming a double arch, one on either side of the median ridge; this is marked by a small V-shaped indent, on either side of which are placed the larval eyes (ocelli), while the compound eyes are seen midway on the lateral raised borders of the glabella, as is usually the case in most trilobites and in the living king-crab. The posterior border of the head-shield (prosoma) measures 15 mm. in breadth across its falcate cornua. The opisthosoma is much narrower; its broadest anterior segment which joins to the prosoma measures only 10 mm. across.

The opisthosoma is semicircular in outline, and is composed of eight distinctly trilobed segments, more or less anchylosed together, and diminishing in breadth from before backwards; the division line

or boundary of the segments can be distinctly traced across the body, being terminated on either margin by a stout falcate spine 2 mm. in length and backwardly curved.

The telson or tail-spine is fairly stout, it is 9 mm. in length, and is strongly ridged down the centre.

This little king-crab approaches the forms described by Mr. W. H. Baily in 1863 from the Coal-measures, Queen's County, Ireland[1] (Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 107, pl. v, fig. 1), but the carapace is more rounded and the genal spines are less sharply bent outwards away from the body; the opisthosoma is also less angular, and there are no tubercles on the median line of the body-segments; the marginal spines also in *B. Baldwini* are shorter, stouter, and stronger than in Mr. Baily's specimens. This is true also of the species *B. bellulus*, König, from Dudley, etc.[2]

In September last I named a new species of *Pygocephalus* from Sparth in honour of its discoverer, Mr. William Albert Parker, F.G.S., of Rochdale, one of the most enthusiastic of workers at the Sparth Beds. To-day I dedicate this *Limulus* to Mr. Walter Baldwin, who has described as well as assisted in finding many beautiful specimens from this locality.

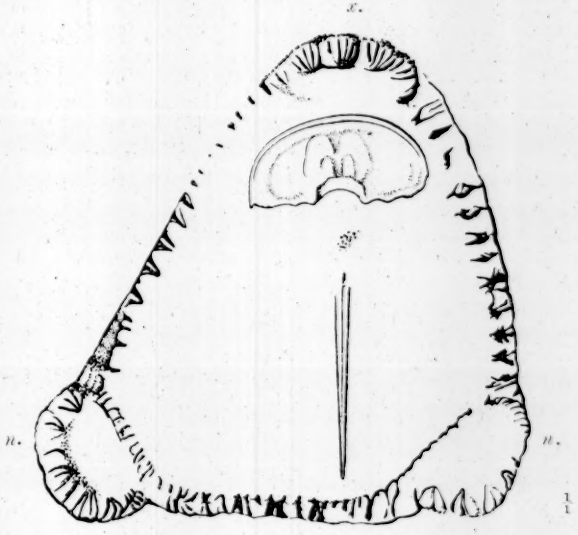


Fig. 2.—*Bellinurus longicaudatus*, H. Woodw., sp. nov. Nat. size. Coal-measures: Sparth, near Rochdale. Presented by Mr. W. H. Sutcliffe, F.G.S., to the Geological Department of the British Museum (Natural History), Cromwell Road.

2. Bellinurus longicaudatus, sp. nov.

The king-crab (Fig. 2) to which I desire to call attention presents some points of unusual interest. It is enclosed in a rather large

[1] H. Woodward, Brit. Foss. Crust., Merostomata: Pal. Soc. Mon., part v (1878), pl. xxxi, figs. 1, 2.

[2] Op. cit., pl. xxxi, figs. 3, 3*a*.

nodule of shale roughly triangular in shape, weighing 2 lbs. 2 oz., and measuring 4 inches across. This nodule has been successfully split open, and reveals upon its plane surfaces a long-tailed *Bellinurus*, lying in the centre of the transverse section of the walls and resting upon the surface of the node of a Calamite stem measuring 3 inches across, to its dark external border. The stem has been squeezed considerably out of its normal circular form into that of a nearly obtuse triangle, having two nodal buds, shown also in section at *n*., *n*., and traces of the woody tissue (xylem) may be observed along the margin at *x*., while outside (not shown in Fig. 2) is a dark carbonaceous band, doubtless representing the outer layer of the stem with traces of the linear leaves of the Calamite.

Plants are nearly everywhere associated in these beds with the remains of Arthropods, suggesting fresh-water conditions and always the close proximity of land. The following is a list received from Mr. Robert Kidston, F.R.S., a year ago, of fossil plants determined by him from the Middle Coal-measures, Sparth, at a horizon 40 yards above the Arley Mine and 40 yards below the Neddy Mine. He had not seen the above-noticed specimen, which was obtained subsequently to his examination of the plants from Sparth.

Dactylotheca plumosa, Artis, sp.
Mariopteris muricata, Schl., sp.
Alethopteris lonchitica, Schl., sp.
,, *valida*, Boulay.
Neuropteris impar, Weiss, sps.
Cyclopteris trichomanoides, Brongn.
Spiropteris sp.
Calamocladus equisetiformis, Schl., sps.
,, *charæformis*, Sternb., sps.
Sphenophyllum cimeeifolium, Sthg., sps. var. *saxifragæfolium*.
Lepidophyllum majus, Brongn.

Fossil of doubtful affinity:—

Vetacapsula Cooperi (Mackie & Crocker).

The following is a brief description of *Bellinurus longicaudatus*:—Breadth of head-shield, or prosoma, 23 mm.; length, 9 mm. Deeply emarginate at the neck-furrow. There is a strongly-marked raised rim around the prosoma, within which is a wide depressed border, which is continued round the latero-posterior margin of the cheeks to the nuchal furrow of the glabella. The glabella approaches nearly to the front border of the head-shield and has a raised border around it, forming a double arch in front with a V-shaped indentation on the median line, which is ridged down the centre; the neck-furrow is raised, strongly arched, and emarginated; the compound eyes occupy a rather backward position on the raised lateral border of the glabella; the genal portions of the shield are well-rounded without prominent cheek-spines at the postero-lateral angles; a raised rim having a flattened border extends around the margin of the cheeks to the neck-furrow. There are faint indications of neck-spines at the posterior angles of the glabella (not shown in the figure). The opisthosoma, which is very indistinct, was probably 8 mm. in length by 15 mm. in breadth, with a short spinose border to its segments; the telson measures 20 mm. in length, and is narrow and pointed.

This is a very well-marked Limuloid, although imperfectly preserved; the head-shield is broader in proportion to its length than is the case in most other species, and the cheeks are very rounded. It is to be hoped that other examples may be met with.

Dr. H. Dukinfield Scott, F.R.S., has figured a Calamite node from Sparth obtained by Mr. W. A. Parker, F.G.S., in 1891, in his "Studies in Fossil Botany," fig. 11, p. 35. Other figures will be found in Professor A. C. Seward's "Fossil Plants," vol. i, 1898: p. 310, fig. 73; p. 316, fig. 77, showing nodes and buds; p. 330, fig. 85 (linear leaves of a Calamite).

The above specimen was obtained by Messrs. W. H. Sutcliffe, F.G.S., and Mr. W. A. Parker, F.G.S., and presented to the British Museum (Natural History).

3. Eoscorpius (Mazonia) Wardingleyi, H. Woodw., sp. nov.

Since the discovery by Mr. W. A. Parker, F.G.S., of the nearly perfect specimen of a fossil Scorpion in the Middle Coal-measures at Sparth Bottoms, Lancashire (described and figured by Messrs. Walter Baldwin and W. H. Sutcliffe, F.G.S., in 1904; see Quart. Journ. Geol. Soc., vol. lx, pp. 394–399, figs. 2, 3), another less perfect example belonging to a distinct species has been forwarded to me for examination. It presents upon the two split surfaces of an irregularly

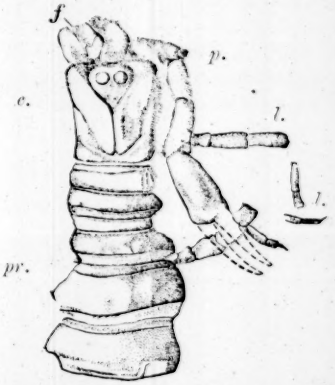


Fig. 3.—*Eoscorpius* (*Mazonia*) *Wardingleyi*, H. Woodw., sp. nov. Magnified one-third nat. size. Middle Coal-measures: Sparth Bottoms, Lancashire. *f.* cheliceræ; *p.* pedipalpi; *l.*, *l.* ambulatory legs; *c.* cephalon, head; *pr.* præ-abdomen. (Only five of the seven præ-abdominal segments are preserved on the split surface of the nodule.)

fractured clay-ironstone nodule the impression and counterpart of an imperfect head-shield, with some of the limbs and five of the præ-abdominal segments attached; the post-abdomen is not preserved. In front of the head-shield the two cheliceræ (*f.*) are seen, and one of the pedipalps (*p.*) or maxillary palpi on the right side and a detached portion of the other on the opposite side[1]; also parts of three or more of the imperfectly preserved ambulatory legs (*l.*, *l.*), which appear to have had only a simple single claw (*not claws*) at their extremities.

The eyes, which are rather close together, are round and prominent, with their lenses directed forwards; they are placed near the centre

[1] Accidentally omitted in figure.

of the head-shield, occupying a raised, heart-shaped area encircled by a depression, outside which is a rounded, raised, laterally encircling border divided posteriorly down the centre line by a narrow groove. The hinder border of the head is narrower and more angular than the anterior, which is slightly rounded. Each segment of the præ-abdomen has a narrow raised ridge along both its anterior and posterior border, and there is evidence of a thinner and more membranous wrinkled integument uniting the stouter chitinous dorsal plates of the several segments together. The two most anterior body-rings are narrower than the hinder segments, and were perhaps ornamented by one or two tubercles upon their surface, in addition to the two raised ridges already mentioned on the anterior and posterior border.

Breadth of head-shield in front, 8 mm.; behind, 7 mm.; length, 10 mm.
Length of cheliceræ, 24 mm.; of walking-legs, 21 mm.
Breadth of orbital prominence, 5 mm.
Breadth of the 1st segment of the præ-abdomen, 9[1] mm.; length, 2 mm.
,, 2nd ,, ,, 8[1] ,, ,, 3 ,,
,, 3rd ,, ,, 10[1] ,, ,, 5 ,,
,, 4th ,, ,, 13 ,, ,, 6 ,,
,, 5th ,, ,, 14 ,, ,, 6 ,,

The form which most closely resembles this scorpion from Sparth (but which unfortunately is also imperfect) was made known by Messrs. Meek & Worthen in 1868, from the Carboniferous formation of Mazon Creek, Illinois, U.S.A. (see Geol. Surv. Illinois, vol. iii, pp. 563–565, figs. A–D), under the name of *Mazonia Woodiana*. It has since been figured in many works, and another example has been described from the Carboniferous series of Joggins, Nova Scotia (see Scudder, Phil. Trans., 1882, p. 650). It has been relegated by Scudder and other subsequent writers to the genus *Eoscorpius* (see Peach, 1882, Thorell, 1885, and Scudder, "Fossil Insects, Myriopods, and Arachnids," Washington, 1891, United States Geological Survey, pp. 25 and 27). Professor Dr. Anton Fritsch, of Prague, in his recent work ("Palæozoische Arachniden," Prag, 1904, p. 77), re-figures it under the old name of *Mazonia Woodiana*, M. & W., fig. 96 in text, but mentions that Scudder in Zittel (Eastman's edition) had adopted *Eoscorpius* as the generic name. *Mazonia* had been represented in the figure as having nine segments in its præ-abdomen, but that most probably was an error due to some obscurity in its preservation or to the duplication of the folds of the integument already referred to, which may have looked like additional segments. We may rely fully upon Mr. S. H. Scudder's determination that only seven segments are really present in the præ-abdomen of *Mazonia*, and as our specimen has only the five anterior segments preserved we need not discuss this point more fully.

There is sufficient distinctive character in the Sparth specimen, when compared with *Mazonia*, to justify us in giving it a specific name, and I gladly comply with the desire of my friend Mr. W. H. Sutcliffe to identify it as *Eoscorpius* (*Mazonia*) *Wardingleyi*, after Mr. Charles Wardingley, F.G.S., of Edinburgh, who carried on

[1] The true breadth of the 1st, 2nd, and 3rd segments is uncertain, as a part of the left side is buried in the matrix, and the nodule resists development.

excellent geological work in the neighbourhood of Rochdale some years ago.

The specimen has been presented by the discoverers to the Geological Department of the British Museum (Natural History).

4. Geralinura (?) Sutcliffei, H. Woodw., sp. nov.

Fig. 4.—*Geralinura Sutcliffei*, H. Woodw., sp. nov. × 3 times nat. size. From the Middle Coal-measures: Sparth, near Rochdale. Original specimen presented to the Geological Department of the British Museum (Natural History).

Among the smaller forms of Arachnids from the Coal-measures the above Figure 4 represents one obtained a year ago from Sparth (enlarged thrice the natural size). The head-shield was either extremely small, or, as is more probably the case, it has been displaced, and we see only the centre of attachment for five pairs of short, stout, ambulatory limbs, whose bases were no doubt situate around or just behind the mouth. These walking-legs are seven-jointed, and terminate in a simple recurved claw. The falces and the palpi are not preserved. Behind the head succeed nine præ-abdominal segments, and a tenth, an extremely small narrow segment, which is no doubt the commencement of the post-abdomen. There are no traces of stigmata on any of the segments; the upper surface is therefore the only one seen upon the two halves of the little nodule. The head-shield is not seen.

1st segment of the præ-abdomen			3 mm.	broad by	2 mm.	long.
2nd	,,	,,	5	,,	2	,,
3rd	,,	,,	5½	,,	3	,,
4th	,,	,,	6	,,	3	,,
5th	,,	,,	7	,,	3	,,
6th	,,	,,	6	,,	3	,,
7th	,,	,,	6	,,	2	,,
8th	,,	,,	5	,,	2	,,
9th	,,	,,	4	,,	2	,,

There is a tenth, extremely narrow, segment just on the edge of the nodule, which is probably the first post-abdominal segment.

The first five segments behind the head are narrower in front and broader along their posterior border; but from the sixth to the ninth this is reversed, as they are broader in front and narrower posteriorly, giving to the body its general elliptical form. Each segment has a slightly raised transverse border and a narrow longitudinal ridge along the median line, and a similar lineation midway on either side; the lateral margins of each segment curve gently outwards, and the posterior angles are slightly produced and pointed backwards.

This fossil is no doubt related to Scudder's genus *Geralinura*, of which four species have been described from the Coal-measures of Bohemia, viz.: *Geralinura Bohemica*, Scudder; *G. crassa*, Kušta; *G. noctua*, Kušta; *G. Scudderi*, Kušta (see Professor A. Fritsch, "Palaeozoische Arachniden," 1904, pp. 61–62); and one, *G. carbonaria*, Sc., from the Coal-measures of Illinois.[1]

This genus is defined by Mr. Scudder as having the cephalothorax (prosoma) ovate, rounded in front, and narrower than the squarely truncated posterior border, with well-rounded sides, not more than half as large as the abdomen, which is cylindrical, sometimes depressed, and composed of nine principal segments, the first three being shorter than the others; and is followed by a post-abdomen of three *much contracted* joints, and this again by the jointed thread-like tail (peculiar to the Thelyphonides). There are a pair of eyes on the front of the cephalothorax. The palpi are large, robust, and coarsely chelate. The legs are moderately long and slender.[1]

Our specimen, although agreeing generally with the above description of the genus *Geralinura* in its body-segments, differs in the shortness of its limbs, whilst the palpi and the head are only imperfectly preserved, nor is the thread-like tail visible. But rather than create a new genus I have placed it provisionally under Scudder's genus *Geralinura*, and dedicate the species to my friend Mr. W. H. Sutcliffe, F.G.S., of Shore Mills, Littleborough, who has liberally presented this and so many other choice specimens to the British Museum.

5. Anthracomartus, Karsch: Zeitsch. deutsch. geol. Gesellsch., 1882, p. 560.

The following is Scudder's diagnosis of the genus:—The cephalothorax (prosoma) is quadrate, the front square, or scarcely convex, half the size of the abdomen (opisthosoma); the coxæ laterally affixed, radiating from a broad triangular sternal plate, the base of which forms the posterior margin. Sides of the body showing a distinct though slight constriction between the prosoma and the opisthosoma, the latter being more convex. Opisthosoma orbicular, a little longer than broad, composed of *seven* segments.

Of this genus Scudder writes: "This is apparently the most abundant type of Arachnida in the Carboniferous formation. Kušta

[1] See S. H. Scudder, "Illustrations of the Carboniferous Arachnida of North America of the Orders Anthracomarti and Pedipalpi," May 7th, 1890, pp. 454–456, pl. xxxix, figs. 1, 3, 4: Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, Boston, 1890.

has noticed four species in Bohemia alone; one is found in Bavaria, one in Silesia, and at least two in our own coal." If we follow Professor Fritsch's classification and include, under the Anthracomartidæ, *Anthracomartus*, *Brachypyge*, *Anthracosiro*, *Eotrogulus*, and *Vratislavia*, we should have to record fourteen species in this very widely distributed Carboniferous family of Opiliones.

1. The first recognised form of British fossil Arachnids of the order Opiliones was described by me in 1871 (see GEOL. MAG., Vol. VIII, pp. 385–388, Pl. XI) under the name of *Eophrynus Prestvici*, Buckl., sp. This was originally noticed by Buckland in 1836, from a less perfect specimen, in his "Bridgewater Treatise," who referred it "to the family Curculionidæ, of which the diamond beetle is a familiar example." He adds: "the abdominal rings are very distinct. I shall designate this insect by the provisional name of *Curculioides Prestvicii*" (Buckland, vol. ii, 1836, pp. 76–77, pl. 46, fig. 2; fig. 1 op. cit. has not been identified). Locality, Coalbrook Dale.

2. The second was figured and described in the GEOLOGICAL MAGAZINE for 1872 (pp. 385–387, Pl. IX, Figs. 1, 2) under the name of *Architarbus subovalis*, H. Woodw., from the Coal-measures of Lancashire, an Arachnide with an elongated form of body. It measures only 16 mm. in length and 7 mm. in greatest breadth, but is more evenly oval in form than is *Geralinura Sutcliffei*, which is more nearly elliptical in outline (see Fig. 4 of this paper).

3. The fragmentary remains of an Arthropod figured and described by J. W. Salter in 1863 as *Eurypterus mammatus*, Salter, from the Coal-measures of Pendleton, Manchester (see Quart. Journ. Geol. Soc., vol. xix, p. 84; and GEOL. MAG., 1873, p. 105, Figs. 1, 2), are still known only from portions of body-segments, but there is little doubt in my own mind that they are parts of a large Arachnide. They agree closely with similar Arthropod remains described and figured by Jordan[1] under the name of *Arthropleura armata*, Jordan.

Similar specimens have come into my hands from the Coal-measures of Fifeshire, collected by Mr. J. W. Kirkby, F.G.S.; from the Coal-measures of Radstock, Somerset, collected by Mr. J. McMurtrie, F.G.S.; and from the Coal-measures near Manchester by Professor Sollas. To these I hope to refer again shortly.

4. Mr. R. I. Pocock has contributed so largely to our knowledge of the recent Arachnida that one is not surprised at his interest also in fossil forms (see his paper on *Eophrynus* and allied Carboniferous Arachnida in the GEOLOGICAL MAGAZINE, 1902, pp. 439–448 and 487–493, with figures of *Eophrynus*, *Brachypyge*, and *Anthracomartus*, pp. 490–491).

5. In 1903 Mr. Pocock continued his researches and described a new Carboniferous Arachnid, *Anthracosiro Woodwardi*, gen. et sp. nov., GEOL. MAG., 1903, pp. 247–251, Figs. A, B.

6. He described a second species of *Anthracosiro* (*A. Fritschi*, sp. nov., op. cit., 1903, pp. 405–408).

[1] See *Palæontographica*, Bd. iv (1856), Taf. ii, Figs. 4, 5, from the Coal-measures of Saarbruck, Rhenish Prussia. See also Pal. Soc. Mon. Merostomata, pt. iv (1872), pp. 163–168.

A table of the orders of Arachnida (after Fritsch) will be found in the Geological Magazine for 1904 (pp. 472–474), which will give a general notion of the fossil forms, of which 39 genera and 67 species are recorded:—

37	Carboniferous and Permo-Carboniferous	from	Bohemia.
6	Carboniferous	from	Silesia.
1	,,	,,	Dresden Museum.
1	,,	,,	Bavaria.
2	,,	,,	France.
1	,,	,,	Belgium.
1	,,	,,	Scotland.
5	,,	,,	England.
1	,,	,,	South Wales.
1	,,	,,	Arkansas, U.S. America.
7	,,	,,	Illinois, U.S. America.

To these we may add:—

1	Scorpion	from the U. Silurian	of	Gotland.
2	,,	,,	,,	Scotland.
1	,,	,,	,,	N. America.

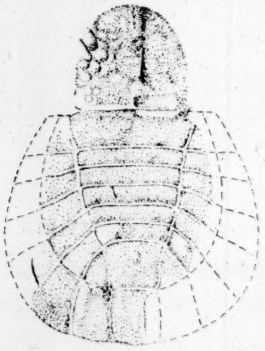


Fig. 5.—*Anthracomartus trilobitus*, Scudder, 1884. Proc. Amer. Acad. Arts and Sci., vol. xx, p. 17; Comptes rend. soc. ent. Belg. (3), No. 62 (1885), p. 85, fig.; Mem. Boston Soc. Nat. Hist., vol. iv, No. 9 (Boston, 1890), p. 451, pl. xxxix, figs. 7–10. Middle Coal-measures: Sparth, near Rochdale, Lancashire. Presented to the Geological Department of the British Museum (Natural History) by Mr. W. H. Sutcliffe, F.G.S.

The specimen from Sparth, like so many other examples of this widely distributed type, displays only the dorsal or tergal aspect of an imperfectly preserved prosoma and a nearly complete opisthosoma of an *Anthracomartus*, which has none of the appendages preserved, and the split nodule containing the impression has but a fragmentary counterpart which assists but little to eke out a description of the other and larger half. The specimen is 24 mm. in length by 15 mm. in breadth. Of this the prosoma is 8 mm. in length and *about* 8 mm. in breadth; the opisthosoma is 17 mm. long by 15 mm. across the widest part, but the margin of the body is more or less broken (see Fig. 5). The opisthosoma shows a median dorsal region which is 8 mm. broad just behind the prosoma, and diminishes in breadth to

3½ mm. at the distal border; from this median region a series of diverging radial marginal plates forms a double row around the dorsal region, both rows having a rounded external margin which runs somewhat parallel at first but gradually widens posteriorly from the anterior margin to the terminal central plate. The horizontal lines of separation between the plates is strongly marked, very straight, and parallel upon the dorsal region of the opisthosoma, but the vertical lines converge from the neck-segment to the seventh segment, which is narrowest and bears a smooth rounded tubercle upon its centre, corresponding to the anal ring upon the sternal aspect of the body. The surface of the opisthosoma is finely granulated. The first segment is nearly twice the length of the second, which is narrowest; the third, fourth, fifth, and sixth segments are nearly equal in length; the seventh is more than twice the length of the preceding one, being even longer than the first segment; the eighth in line is not probably a true segment, but a post-anal plate, and corresponds to the 'telson' or tail-plate of *Limulus* and *Eurypterus*.

I do not propose to make a new species upon this very interesting little Arachnid, but prefer to refer it to Scudder's species of *Anthracomartus trilobitus* from the Carboniferous formation of Fayetteville, Arkansas, United States, with the description and figures of which it most closely agrees (see Scudder, Carb. Arachnida N. America, May, 1890, pp. 451–452, pl. xxxix, figs. 7–10; Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, Sept., 1890, Boston, U.S.).

VI.—Notes on some Coastal Features in Co. Waterford.

III. Tramore Bay to Dunmore East.

By F. R. Cowper Reed, M.A., F.G.S.

THE projecting mass of land between Tramore Bay and the mouth of the River Suir consists of Old Red Sandstone, and the cliffs are mostly high, bold, and precipitous. The valleys which descend to the sea are more or less filled with Boulder-clay and other drift materials, testifying to their pre-Glacial excavation. The geological history of these valleys and of the large shallow lagoon lying inside the long spit of sand dunes which nearly cuts off the head of Tramore Bay deserves a separate article, and we will therefore here commence with the description of the eastern shore of this bay stretching from Summerville to Brownstown Head. Messrs. Wright & Muff[1] in their paper on the pre-Glacial shore-line of the South of Ireland made no reference to this portion of the Waterford coast.

The cliff below Summerville House is composed of the usual type of Boulder-clay of the district, but devoid of any large boulders; it is capped by 4–8 inches of whitish to yellow marl without any stones; above this comes 1–2 feet of wind-blown sand immediately beneath the thin soil. The Boulder-clay here is only about 6 feet thick, and the total height of the cliffs is only 8–12 feet. The line of these

[1] Scient. Proc. Roy. Dublin Soc., vol. x, pt. 2 (1904), pp. 250–324.

drift-formed cliffs recedes inland behind the large triangular area of grass-grown hummocky land which projects seawards at Bass Point; this area represents a comparatively recent accumulation of sand which has been built outwards for some 200 yards from the base of the cliffs so as to narrow the channel of Rinnashark Harbour leading into the Back Strand lagoon.

Outside the mouth of the harbour the base of the drift cliffs is washed by the sea at high tide, and their height has increased to over 20 feet. Their lower 10–20 feet are here composed of wind-blown false-bedded sand, and on this rests 2–3 feet of yellow Boulder-clay. A layer of drift sand 1 foot thick rests on the latter, and then come the subsoil and soil. This succession can be traced for about 75–100 yards along the shore, but the thick lower sands then die out, and a dark greyish clay, 4–8 feet thick, comes in beneath the Boulder-clay; it is full of small angular fragments of black slate, and in some places rests directly on the Old Red Sandstone, but in others on very coarse 'head' composed of large angular or subangular fragments of the Old Red conglomerates, flags, and sandstones of the locality. This head must undoubtedly be correlated with Messrs. Wright & Muff's Lower Head, and is of strictly local origin; it reposes directly at this spot on the smoothed pre-Glacial platform which has been cut across the alternating succession of hard and soft beds of the Old Red Sandstone.

Portions of the rock-platform, more or less dissected by recent marine erosion, can be observed under the cliffs, and it does not appear that it was in the first instance planed down to a uniform level surface. Its average height above present high-water mark is 3–4 feet, but in places, owing to its uneven surface, it is as much as 10 feet.

As for the pre-Glacial cliff, it is obvious that it does not run quite parallel to the present coastline; and it seems to lie a little distance inland, being indicated by an abrupt change in the declivity of the hillside, and frequently also by a line of small scars at the top of the nearly horizontal shelf or terrace of drift which extends outwards as a distinct feature of varying width along much of the eastern side of Rinnashark Harbour to end abruptly in the present cliffs of drift, 30–40 feet high. Post-Glacial erosion has not as yet been sufficient here to cut back the drift deposits as far as the old cliff.

The Boulder-clay (of the usual type) increases in thickness as we proceed southwards along the coast, and attains a thickness of 20 feet in the cliffs. Here and there above it we meet with patches or pockets of what may be regarded as the representative of the Upper Head in the shape of a deposit of small angular or subangular fragments of Old Red Sandstone closely packed together, and with a thickness of about 2–3 feet. But usually the sole deposit above the Boulder-clay is blown sand of recent date.

Outside Rinnashark Harbour the pre-Glacial cliff curves out westwards so as to meet the present sea-margin, and the drift deposits are then seen banked up against the solid Old Red Sandstone, which from this point onwards forms the modern cliffs. Except in a few sheltered spots or original coves the pre-Glacial cliff has been

cut away by recent erosion on this exposed bit of coast; but here and there for nearly a mile southwards, i.e., as far south as the cove named Cooneenclogher, traces of it may be met with. The Lower Head with the old beach-deposits below it are occasionally extremely well exposed in these spots. The patches of the beach-deposits measure from 1–2½ feet in thickness, and consist of bedded shingle and sea-sand arranged in definite layers, well-rolled pebbles of the usual ellipsoidal shape in a matrix of fine sand forming the basal bed. The pebbles appear to be entirely of local origin, and are mostly rounded fragments from the Old Red conglomerates. A few such well-rounded pebbles can generally be found at the base of the coarse Lower Head in cases where definite beach-deposits are absent. The Lower Head itself is extremely coarse, and consists of huge blocks of the Old Red Sandstone series of the cliffs, mostly of irregular angular shape, but some with rounded corners. Tabular masses of the sandstones or flags, shapeless blocks of the conglomerates, with smaller fragments of the same, and a little fine red sand compose the deposit, which frequently possesses a thickness of 12–14 feet. The large component blocks lie at all angles, and are often as much as 3–4 feet long.

The Boulder-clay which rests directly on this head contrasts strongly with it in colour, and the line of junction is clearly marked and fairly regular. In one place the head is well seen banked up against the pre-Glacial cliff, which is worn and rounded off at the top, as Messrs. Wright & Muff have noticed elsewhere. The Boulder-clay here overlaps the head and comes to rest directly on the solid rock, the head merely filling up the angle at the base of the cliff. It is remarkable that no disturbance of the loose materials of the head seems to have taken place when the Boulder-clay was deposited; the glaciation cannot have been intense at this point.

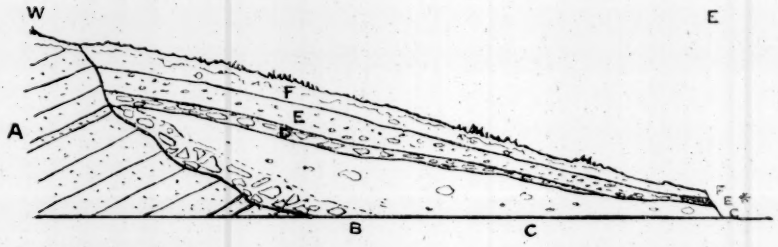
Rathmoylan Cove.

The section in this locality is chiefly interesting from the clear development and coarse nature of the Upper Head at the mouth of a small pre-Glacial valley. This valley runs down to Rathmoylan Cove, and is more or less filled with drift deposits. The present stream has cut down into them to some extent so as to form small cliffs 4–5 feet high along the lower part of its course, but the rocky floor of the pre-Glacial valley must be sought at some depth below the modern beach-level where the stream now enters the sea. The cove is shut in on the east and west sides by walls of solid Old Red Sandstone, and is in reality the flooded lower end of the old valley, from the mouth of which marine erosion has removed the soft beds of drift which are now exposed only in the cliff forming the head of the cove.

This cliff rises from nearly beach-level by the road leading down to the strand to the top of the bounding ridge on the west, giving a cross-section of one side of the valley. Small landslips, rainwash, and vegetation obscure the actual face of the upper part of the pre-Glacial slope, but the steeply-sloping rocky side is well seen

nearer the base of the cliff. Resting directly upon it we find a deposit which must undoubtedly be correlated with the Lower Head. This bed has a thickness of 3–4 feet, conforms to the solid rock-slope on which it reposes, and disappears with it below the present beach-level a few yards out from the western angle of the beach. It is composed of purely local materials derived from the immediately adjacent beds of the Old Red Sandstone flanking the valley; the fragments are not sorted according to size, but are roughly arranged in layers, and, though the larger ones (some are 2–3 feet long) are angular, the smaller ones, consisting of the soft red sandstone of the cliffs, are more or less rounded, and there are intermixed a few small rounded quartz pebbles similar to those in the neighbouring conglomerates.

Section of Drift at Head of Rathmoylan Cove.



A. Old Red Sandstone.
B. Lower Head. 3–4 feet.
C. Boulder-clay. 6 feet.
D. Upper Head. 1 foot.
E. Sandy shingle, 1½–2 feet thick, thinning eastwards and replaced by clay at E*.
F. Subsoil and soil.

Resting on this head, but not as clearly marked off from it as usual, is a reddish Boulder-clay containing many small rounded pebbles mostly of quartz or of the Old Red conglomerates, with comparatively few large or angular fragments. These few, however, are frequently glaciated and scratched, and in addition to boulders of the immediately local rocks there are others of a more distant origin; thus, there are angular fragments of a greyish felsite showing beautiful fluxion structure and banding, and there are well-rounded boulders and pebbles of a fine-grained whitish quartzite. Less common are subangular small slabs and chips of black slate, more or less rounded boulders of a greenish felsitic ash or felsite, and much weathered and honeycombed pieces of Carboniferous Limestone. The total maximum thickness of the Boulder-clay here seen is about 6 feet, and it appears to thin out against the valley side and to overlap the Lower Head in the other direction.

Above this Boulder-clay comes a regular but unusually coarse deposit which must be correlated with the Upper Head. It is 1 foot thick and consists of closely-packed and irregularly bedded angular slabs and blocks of the local sandstones of the Old Red identical with those

of the present sea-cliffs. These are intermixed with a few fragments of the conglomerates, some of which are rounded, and there are a few non-local rocks like those in the underlying Boulder-clay. There is scarcely any fine matrix to the bed. The red sandstone fragments average 4–6 inches in length, and often have their angles rounded off, but towards the cliff they increase in size, number, and angularity, attaining a length of 1–1½ feet. The slabs mostly lie flat, being arranged in a decidedly parallel manner so as to give to the bed the appearance of stratification, but there is no sorting according to size, except in the horizontal manner above mentioned. This deposit is very distinct and definitely marked off from the other beds. It dips at a much lower angle to the valley-floor than the rocky slope on which the Lower Head rests, and follows the slope and contour of the present ground, as seen by the edge of the cliff of drift in which it is exposed. At about 20 yards from the western corner of the beach it loses its distinctive characters, thinning out and merging into an overlying bed of sandy shingle. This bed of sandy shingle is a regular deposit, 1½–2 feet thick, consisting of small well-rounded pebbles and sub-angular fragments of the Old Red rocks, of fairly uniform size and roughly bedded in sand; it overlaps the Upper Head eastwards in the cliff section, itself then thinning out and being replaced by a sandy bed without stones 6 inches to 1 foot thick and resting directly on the Boulder-clay. The materials of which this bed of shingle and sand are composed bear the obvious marks of arrangement and deposition by running water. Resting upon this bed come a clayey subsoil and soil, in all about 2 feet thick, almost devoid of rocky fragments and pebbles.

Just as in the section at Fornaght Strand (Geol. Mag., Dec. V, Vol. IV, 1907, p. 17), we find here deposits of water-borne materials combined with the subaerial and coastal accumulations of pre-Glacial, Glacial, and post-Glacial times.

The Boulder-clay of this portion of the coast does not contain the large masses of granites, gneisses, and metamorphic rocks which we have described near Passage (ibid., p 501). Most of its non-local rocks might have been derived from the weathered débris of the neighbouring Old Red Sandstone conglomerates, which contain a most varied assortment of rocks. The greater part of the shingle of the existing beach appears to have been derived from this source. But the fragments of Carboniferous Limestone must have been brought from the country to the north by the ice or some other transporting agent; and there is so far no reason for thinking that the Boulder-clay here was the product of any ice-sheet but that from inland. There is no evidence that the Irish Sea ice touched the coast in this part, and no flints or marine shells have been found in any of the beds of drift.

The relations of the present and ancient watercourses and of the inland topography to the movements indicated by the coastal features are still under examination, and promise to throw considerable light on the later stages in the geological history of the country.

NOTICES OF MEMOIRS.

Desert Conditions and the Origin of the British Trias.[1]

By J. Lomas, A.R.C.S., F.G.S.

(*Concluded from the November Number, page* 514.)

THE occurrence of salt lakes in deserts is of the greatest interest and importance in the quest we have set before us. They are so characteristic of arid regions that it is essential we should have a clear impression of their peculiarities if we wish to make a true comparison with the rocks of the Trias. They have been described so frequently by travellers that I need only quote one or two examples.

Munzinger,[2] in the "Narrative of a Journey through the Afar Country," describes the great salt basin to the east of the Abyssinian mountains as bordered with walls of gypsum. Further he writes: "The first part of the salt basin is sandy, but after a short distance clay appears on the top, and every now and then we found a rain-ditch with powdered salt in it. After 1½ hours march we found a line of potasse trees, otherwise no tree or bush. The soil by degrees becomes of a greyish tint, and further on resembles a frosted ploughed field; but at the end the bed of salt becomes more thick and hard and presents the appearance of a lake frozen over."

Captain C. G. Rawling,[3] in exploring Central Tibet, visited numerous salt lakes. Of Gore Tso he writes: "A fine lake was seen two miles to the east, but mounds of some white mineral, piled up along the banks, almost certainly indicated that the water was undrinkable. Although this was the 5th of July, the lake was frozen from end to end. . . . On the following morning I made my way to the shores of the lake and found . . . all around rose a solid ridge of salt deposit, three to four feet high and from thirty to forty feet wide. No vegetation grew within 500 yards of the shores, while to the north a barren plain stretched away for many miles. The lake is about 20 square miles in area."

Sven Hedin, writing of the Takla Makan desert, states that the dunes are arranged in a sort of network pattern with hollows—or bayirs—inside the meshes. Clay rises as oblong terraces or steps four to five feet high along the slopes, giving the appearance of beach lines. The bottom of the bayir is covered with a granular hard incrustation of salt, at a distance resembling rime. Upon digging eight or nine inches a thick deposit of pure salt is reached, evidently filling the bed of a desiccated salt lake, the margins and side terraces of which are coated with perfectly horizontal layers of yellowish-red clay eight to nine inches thick and hard as stone. In some bayirs a part remains moist, and is edged all round with a narrow belt of salt. A bed of gypsum was observed in some cases, and one contained the skeleton of a water bird and a dead day-fly.

[1] Proc. Liverpool Geol. Soc., vol. x, pt. 3, 1907, pp. 172–180; slightly abridged.
[2] Geog. Journal, 1869, p. 200.
[3] "The Great Plateau," p. 61.

The above excerpts give one a good idea of what the desert salt-lakes are like, and one or two facts common to all are worth noting. First, we have the clay bottom sometimes augmented in thickness by layers of sand which have drifted into the pool; then we note the constant association of salt and gypsum in the deposits. It is well known that concentrated brine precipitates the sulphate of lime out of solution. Further, we have no mention of carbonate of lime as one of the constituents left after evaporation, or, at least, if present it is not in sufficient quantity to call for special notice. Yet in the waters flowing from the hills towards the lakes this substance, as the bicarbonate of lime, must have been present, and probably exceeding the others in amount. The explanation is simple. The bicarbonate is chemically not a stable compound, and readily parts with the excess of carbonic acid. Hence, in passing over or through the soils the carbonate of lime will be precipitated and form the nodules and limestones described above, while the more chemically stable compounds will reach the lakes undiminished in quantity.

So it happens, as we should expect, that carbonate of lime segregates on the land, while salt and gypsum are the chief substances left as residues in the desiccated pools. Dolomite in perfect rhombohedral crystals is occasionally found in association with the products of desert pools.

Drifting sands blowing over the plains may fill up the hollows and leave no sign on the surface of the pools which formerly existed there. The lake deposits would still be there buried under the sand, and if a section could be made through them we should find beds composed mainly of sand with thin bands of clay following the limits of the lake and irregularly disposed at various horizons. On the margins the clay would show desiccation cracks and ripple-marks, the footprints of animals, and the remains of such forms of life as find a suitable habitat under such conditions.

Mr. T. H. Holland,[1] referring to the deposits in the Rajputana Desert, states that silt beds occur, filling in hollows in the Archæan surface. They have a general plano-convex lens shape, and are charged with salt, beds of gypsum, and concretionary nodules of carbonate of lime.

In our Triassic rocks we get the exact counterpart of these filled-in desert lakes. Bands of clay occur in all the divisions, but they are more common in the higher beds. When the full extent of the clay bands can be determined, they are always half lenses in shape, with the convexity downwards. It is on the lower surfaces of the sandstones, immediately resting on the clay, that we find casts of footprints, raindrops, ripple-marks, and desiccation cracks, and the clays often either contain pseudomorphs of rock-salt or deposits of this mineral and gypsum overlie the clay. The salt beds of Cheshire have these associations, and are now generally regarded as resulting from dried-up pools or lakes. Even when beds of pure salt are absent it is found that water from the Keuper Marls is almost invariably strongly impregnated with salt. It may be that where beds of pure salt are

[1] Brit. Assoc. Report, 1906, p. 575.

found they have been covered by drifting sand after complete desiccation of the pool, and when the salt is intimately mixed with the rock the wind-borne material was deposited in the pool while some water remained.

Dr. Cullis has recently described the occurrence of dolomite crystals in the Keuper Marls of the West of England. So far they have not been found in our locality, although carefully looked for.[1] We cannot say at present how these crystals have been formed, but their presence in recent deserts and in the Triassic rocks is of interest.

When dealing with the subterranean water supply of the desert it was pointed out that the impermeable bands which confine the water below show very striking differences of level. If these bands of clay can be regarded as the silt covering the floors of filled-up pools our difficulties are most satisfactorily met. (See p. 512.)

Thus far we have dealt with the part water plays in the economy of the desert. The waste of sand stretching as far as the eye can reach gives little sign of the activities below the surface, and it is chiefly there that water has its work to do.

Surface Deposits.—We turn now to discuss the surface deposits themselves. It must not be supposed that even in the so-called sandy deserts the surface is uniformly covered with loose fragmentary materials. In the Algerian Sahara probably less than one-third is covered with sand. Solid rock forms the floor of vast barren plains, or stands as islands or cliffs washed by great seas of sand. However, it is mainly with the sand (and in this term we may for convenience include pebbles) that we have to deal.

Origin of the Sand.—The sands of the deserts were naturally at first attributed to marine action, and the presence of salt deposits no doubt gave verisimilitude to the idea that they represented dried-up sea-bottoms. Zittel, Tissandier, and others have shown that the fragmental material is of subaerial origin, and has been derived by the action of the ordinary disintegrating forces at work on the land.

In a climate such as ours it is hard to appreciate the importance of one of the most active disintegrating agents in the desert. One needs to stand under the tropical sun and in the presence of the riven rocks to fully appreciate what sun-flaking means. Unprotected by vegetation or covering soils the bare rocks become intensely heated during the day; when the sun's heat is withdrawn they rapidly chill by radiation, and thus by alternate expansion and contraction even the most compact and resistant rocks yield. A characteristic form assumed by sun-flaked rocks is the spheroid, and one is reminded of the spheroidal weathering often seen in basalt. In a cuboidal mass of granite the solid angles are the first to split, and then the edges go, and so flake after flake is removed until the block resembles a well-worn boulder. The flakes are usually from half an inch to a little more than an inch in thickness, but their horizontal extent may be many yards. After flaking, the smooth curved surfaces give one the impression of *roches moutonnées* when viewed at a distance, and

[1] It might be noted that dolomite occurs in plenty in the sands dredged from the Mersey bar.

individual spheroids resting on these surfaces resemble perched blocks. At the foot of a cliff screes of angular flakes tend to accumulate. These still further break up under similar influences and finally form sand. They may accumulate until the rock is buried under its own fragments, or in the rainy season the loose material may be carried away to form sandy deltas, and the surface of the solid rock may be kept open for further flaking. Sands resulting from the disintegration of granite and other rocks in the desert are in striking contrast to those formed in our own country in so much as chemical action takes no part in the breaking down of the rock. The fragments are chemically unaltered, and the flaked surfaces consist of perfectly fresh minerals. Of course, in the neighbourhood of mountains sufficiently high and conveniently situated to intercept moisture-laden winds, both chemical and mechanical disintegration may take place and streams may flow into the lowlands, mingling water-borne material with that of desert origin.

It is difficult to apply the tests of sun-flaking and the characteristics of desert sand to our Triassic deposits, as so few places exist where they are seen to lie on the rocks which gave them their origin. However, in the neighbourhood of Leicester, in Charnwood Forest, on Mount Sorrel at Croft, and at other places where the Keuper rests on the igneous rocks we get the very best conditions for making the comparison. Professor W. W. Watts has shown that in this district the Keuper fills up hollows in the older rocks, and denudation is now uncovering the old pre-Triassic landscape. The older rocks, particularly at Mount Sorrel, present curved flaked surfaces exactly like those described from the desert. Loose blocks are flaked into spheroids and lie tumbled in the Keuper Marls, which must have been accumulating at the time the blocks fell from the cliffs above. Screes of angular flakes rest against the ancient slopes, and the sand is composed almost exclusively of material from the adjacent rocks. Moreover, the surfaces of the rock, the scree material, and the sand are all chemically fresh.

The absence of decomposition products is well seen, too, in the Keuper sandstones of our own neighbourhood in places where infiltration has not taken place. When a clay band occurs in a rock face, the felspars in the top portion are usually kaolinised by the percolation of surface waters, but below the impervious layer they are remarkably fresh. This conclusively demonstrates that when they were laid down they were not subject to chemical changes.

Work of the Wind.—During the dry season the wind does its own work in carrying, sifting, rounding, and etching.

(1) *Carrying.*—In open ground driven sand tends to accumulate in ridge-shaped masses, the long crests lying transversely to the wind. When a dune of this kind has been originated the wind blows grains up the exposed slope and over the summit, where they drop on the leeside. The slope to windward is gentle, and on the leeside steeper and slightly concave. The concavity is due to a backward eddy which sets in as the wind passes over the crest, and can easily be demonstrated in our local sand-hills by putting a piece of paper or any light object against the leeward slope when a stiff wind is blowing. The paper will be seen to move up the slope against the wind.

In our neighbourhood the dunes seldom exceed 50 feet in height, but in the desert they have been measured up to 350 feet. A favourite simile with travellers is to compare dunes with the waves of the sea, with crest and trough following each other parallel in sequence or arranged in a network pattern.

One fundamental difference must be kept in mind; in the sea the wave motion progresses while the material is stationary. In the desert the sand travels with the wave movement. The Arabs say that the dunes 'walk.' It follows, then, that if the material goes forward the country to windward will be left bare unless fresh material is forthcoming from that quarter. Deposits accumulated by wind action show very characteristic false bedding. The nature of this depends on the steepness of the slope over which the sand tumbles and the varying directions of the wind. When the slope to leeward is very steep the weight of the sand at the top may cause the sand to slide down into the hollow, thus puckering and folding the layers beneath.

The distance to which sand may be carried by wind is very great. Dust-storms are sometimes met with in the Mid-Atlantic which can only have come from the western Sahara. At Las Palmas a ridge of sand dunes exists on the low isthmus connecting the Port with Isleta. The rocks of the island could not yield such a deposit, and captains of ships attribute the sand to winds blowing from the African continent. The finest sand dust may be carried in the air for hundreds of miles, and when the winds are constant the result will be the building up of thick masses of stratified material. Such is the origin attributed to the Loess of China, which attains more than a thousand feet in thickness, and Richthofen supposes it to have come from the desert areas of Asia. Professor N. S. Shaler[1] assigns a similar origin to the accumulation of fine-grained detritus in the Western Mississippi Valley, and he states that it has been derived from the Cordilleras.

(2) *Sifting.*—The sifting action of wind may be observed in a dusty road or in our local sand-hills. In deserts, however, where the winds blow more consistently from one quarter, the action is more perfect.

In a series of samples taken in the Sahara from the same locality in vertical sequence by the late Dr. Isaac Roberts the grains differ in size at each horizon, but for the same depth the sifting is so perfect that it looks as if each sample had been put through a sieve. Many other observers have commented on the sifting action of wind, and it is only reasonable to suppose that the size of a grain carried along will vary with the velocity of the current which moves it. Sven Hedin graphically describes a sand-storm he encountered in Central Asia. Near the ground the wind velocity was 40½ miles an hour. Six feet from the ground it measured 58½ miles an hour. Branches, tufts of grass, and grains as big as peas whirled in the air and struck his face with stinging force. A strong wind such as that described will move large and small particles alike, but as it loses velocity the particles will drop to the ground as the carrying power of the wind diminishes. Thus the sands raised by one storm will be graded horizontally,

[1] U.S. Geol. Survey, 12th Report.

gradually getting smaller to leeward. The same sands may be worked up again and again by currents of differing velocities, and hence we should not expect to find the layers of even-sized grains to persist over very great distances. Again, the grains are not all composed of materials having the same relative density. Although quartz predominates, we find mica, felspar, magnetite, zircon, and other minerals, and each will be affected according to its linear dimensions and specific gravity.

If we consider two particles of different sizes and having the same terminal velocities when falling under gravity we find the resistance varies as the square of the linear dimensions, and the weight jointly as the cube of the linear dimensions and the specific gravity. This is only a very simple and incomplete way of stating a very complicated problem, but it is possible to find in terms of their relative densities and dimensions the sizes of the different kinds of grains which will come to rest together.

We have already seen that where temporary streams flow down from high grounds fans of gravel are produced where they debouch into the plain, and along the beds of watercourses there exist layers of gravel, composed of water-worn stones. The distance these stones have travelled from their place of origin depends on the character and volume of the stream which brought them. It may be reckoned in miles or scores of miles. We pictured above (p. 511) the character of the deposits formed by the successive excavation and filling up of river valleys, and gave instances where sands with bands of pebbles intercalated at various horizons had resulted from this action. What is the effect of winds blowing over a deposit of this nature? The sands are carried by the air currents and form dunes, but the larger stones are too heavy to be moved and form a loose pavement on the desert floor.

According to Mr. H. T. Ferrar, of the Geological Survey of Egypt, these pebble layers may be so thin that the tread of a camel may break through and send up puffs of the sand from below at every step. At other times they are more than 100 feet thick. These may result either from excessive rainfall and strong currents of water or from the successive accumulation of materials brought down by streams through many wet seasons, and the removal of the finer material during many dry seasons. In any case, we have in deserts great spreads of gravel brought down by rivers and reassorted by wind action.

(3) *Rounding and Etching.*—Sands caught up by the wind and hurled against each other have a greater velocity and hence a greater impact than those carried along by moving water. In river and sea sands rounding does take place, but it does not approach the perfection seen in sands which have been subject to prolonged movement in air. The constant battering of grains against each other not only results in rounding, but in the production of excessively fine splinters of sand. It is this sand dust which is carried to great distances by winds and tends to accumulate on the lee sides of desert regions. Particles too heavy to be lifted bodily in the air are rolled along the ground. If it happens that the length of

a grain is great as compared with the width the rolling may be confined to one axis of revolution and a cylindrical form results. Cylindrical grains of this nature are not uncommon in desert sands, and they are found in the dunes round our coasts. The sands rolling up a slope often form the most exquisite ripples, giving the appearance of tiny dunes riding on the larger ones. Perfect spheres do not, as a rule, result from the attrition of very small grains, and we seldom find 'Millet seed' sands with a diameter of less than ·5 mm. Not only does abrasion take place by the striking of one grain against another, but the battering of grains against the solid rocks or against loose stones lying on the surface of the desert results in some characteristic effects. The effects produced on the rocks will vary not only with their hardness and texture, but also with the angle at which the impact takes place.

A glass tumbler dropped by a tourist in the desert was found after a time to be frosted and opaque on those parts exposed above the sand. It exactly resembled the sand-blast labels on our reagent bottles and the designs frosted on glass intended for ornamental purposes.

Blocks of obsidian found in the deserts of Iceland likewise become frosted on their exposed surfaces. Granite on the other hand takes a beautiful polish. If the rocks contain minerals of varying hardness the softer constituents tend to form hollows, while the harder materials stand out and are sometimes completely disengaged from the mass. In this way the fossils in the nummulitic limestone of which the Great Pyramid is built stand out from the surface, and large numbers of loose nummulites can be found in the sands surrounding the base of the pyramid. So perfectly and so intimately does the sand pick out the parts of superior hardness, or of looser texture, that pieces of silicified wood can be found in the neighbourhood of Cairo with the vascular fibres standing out from the less compact parenchymatous tissue.

Mr. W. D. Brown[1] recently described before the Liverpool Geological Society some most interesting experiments which he performed with artificial sand blast on various rocks. He showed that a blast with a pressure of 45 pounds to the square inch, acting perpendicularly on sandstone, drilled a cylindrical hole and removed 435 grains in 5 minutes, whereas the same blast acting on the same piece of rock at an angle of 45 degrees produced an even plane surface and only removed 400 grains in 10 minutes. A piece of granite with an oblique blast lost 200 grains in 5 minutes, while limestone lost 323 grains in the same time and under similar conditions. All the stones subjected to the experiments possessed rounded surfaces before being acted upon, but the sandstone and limestone were reduced to plane surfaces while the granite showed differential action, the quartz standing out from the softer constituents.

The production of a plane surface by oblique sandblasting may be compared with the action of a file drawn over a curved surface. Being rigid, the file moves in a straight line, it does not accommodate

[1] Proc. Liverpool Geol. Soc., vol. x, p. 130.

itself to the outlines of the substance, but produces a sharp cut edge where it leaves the object. Similarly, sand moving with great velocity keeps its initial path, while similar particles moved slowly by a current of water over a curved surface would roll over the leeward slopes and abrade during their descent. It must not be concluded that a plane surface can only be produced by the action of wind-driven sand. In Switzerland I have seen plane surfaces and sharp cut edges, produced in the beds of torrents carrying sand in suspension, quite indistinguishable from those produced by wind action. The plane surface then is largely a result of high velocity, and while this is of rare occurrence in currents of water it is common in currents of air.

When driven sand strikes a stone in the open desert it is deflected upwards and round the sides so that plane surfaces are formed on three planes. This is the typical form to which the name 'dreikanter' has been applied, and the finding of these in any deposit is regarded as one of the surest indications of wind action.

Sand blowing over a flat surface of rock tends to widen joints and open them out into a funnel shape, with the wide end facing the direction of the wind. The sides of the opened joints, too, are almost invariably undercut.

It has been shown by Professor Watts, Mr. Walcot Gibson, and others that the surface of the country had been carved by denuding forces into valleys and hills before the Trias was deposited. The newer rocks, by filling in the low grounds, smoothed down the landscapes, and in some places hills were completely covered. In no part of Britain do Triassic rocks attain a greater altitude than 800 to 900 feet above sea-level at the present day, and we have no proof that they ever extend much above this level. They are essentially deposits of the lowlands. Their distribution has been admirably summarised by Professor Bonney,[1] and I can add nothing to his lucid description of their occurrence. He shows that there exist two foci of coarse fragmental rocks, one in the western and northern Midlands and the other in Devonshire. No one now doubts that Professor Bonney is right in claiming these coarse deposits as of fluviatile origin. At the places mentioned, rivers reached the plains (whence they came does not matter at present) bringing down pebbles, well worn in transit, and no doubt a large amount of finer material as well.

Taken as a whole the deposits get finer as we go away from the foci, and on the extreme borders of the areas covered by Trias they consist of exceedingly minute fragments. At a subsequent stage in the history of the Trias, pebbles occur again, indicating a return to the conditions under which the lower beds containing pebbles were formed.

Assuming that desert conditions prevailed during Triassic time—interrupted, perhaps, by pluvial periods, when rapid streams brought down the pebbly constituents—let us see how far they show evidence of the action of wind. Except in the finer deposits such as the Keuper Marl true bedding is almost entirely absent. Current bedding there is in plenty, and frequently very steep—too steep, indeed, for the angle of rest of sand laid down in water. In extreme cases of steep false

[1] "On the Origin of the Trias": Proc. Yorks. Geol. Soc., vol. xvi (1906), p. 1.

bedding the sands are often contorted at the bottom of the basin as though the weight of the sands above had caused a slide such as we have described as taking place in sand-hills.

It is difficult to describe the structure of the sandstones; there are no geological terms exactly suitable. They have the appearance of a tumbled series of eroded lenticles. Anyone who has had the misfortune to map them knows how the beds thicken and thin out promiscuously, and how difficult it is to find a datum-line which will be of service in correlation. Even our late member and founder, Mr. Morton, whose knowledge of our local rocks was so intimate and extensive, would never give an opinion as to the horizon of a piece of Trias sandstone from a hand specimen. The only approaches to satisfactory datum-lines we possess are the two horizons where pebbles occur, and even these are only of service locally, as they are limited in extent. In sections cut through dunes in the desert between Ismailia and Kasassin I have seen beds very much resembling those I have attempted to describe above.

The marginal beds of the Trias area are almost without exception the Keuper Marls. They are found also covering the sandstones in the middle of the area, and sometimes they are intercalated with beds of sandstone. They are not strictly marls, but are composed almost exclusively of exceedingly fine and angular quartz dust. It has been suggested that they have been laid down in a lake, or a series of lakes, and the even bedding which they show is given as a proof. But bedding even more perfect may be seen in volcanic dust deposited on the land, and, further, Mr. T. O. Bosworth has shown that when the Keuper Marl rests against a sloping cliff the bedding slopes with the surface of the ground. This is quite unlike the conditions we should expect to find if it had been of subaqueous origin. Lakes of the desert type are found as local phenomena in the Keuper Marls, and have been referred to in a previous part of this paper. The marls may represent the smallest tailings of wind-carried material.

The sifting action of wind is everywhere evident in the Trias. Besides the horizontal grading already mentioned which characterizes the deposits broadly as a whole, we find that locally the same sifting influences have been at work. Sands of exactly the same dimensions occur as lenticular patches, a few feet or several yards in length. These are associated with other lenticles of larger or smaller grain, but in the same patch there is no admixture of large and small sizes. In our neighbourhood they are best seen at the top of the Bunter, immediately underlying the Keuper basement bed. The perfection of sifting into sizes shown at Bidston and at Scarth Hill is marvellous, but in other places and at other horizons the some features may be observed.

The concentration of pebbles from river deposits is also paralleled in the Trias. The pebble beds of the Midlands, although originally of fluviatile origin, do not exhibit the characteristics of river action. The individual pebbles show no orientation in the arrangement of their longer axes, but are wedged together in a tumbled mass as if they had dropped into their present situations by the removal of material about them. The insecurity of their positions is evidenced

by the pitting which has resulted from their successive readjustments. The interspaces between the pebbles are almost free from sand, but lenticular seams of sand occur, which may have been protected from removal by wind, when the pebbles formed a continuous covering. There are places in our own district where it does not appear that concentration took place, and the sand with pebbles marking the situations of temporary streams still persist as originally laid down.

The occurrence of millet-seed sands in the Trias is too well known to need further comment, and they have always been attributed to wind action. Professor Watts,[1] too, has shown that the surfaces of the Mount Sorrel granite, when freshly uncovered from the mantle of Trias, show very characteristic wind etching, and at Croft the underlying igneous rocks have their joints widened and their vertical faces undercut in a way that could only be produced by wind. 'Dreikanter' occur sparingly in the pebble deposits. They are not common even in recent deserts, for only the surface pebbles can come under the influence of the wind.

This paper is not intended as a description of the Triassic rocks themselves, but to institute a comparison between the features and activities of existing deserts and the Trias rocks of our own country. The question has been discussed entirely from the physical standpoint. The palæontological aspect still remains to be considered. The animal and plant associations, and their adaptations to the peculiar circumstances under which they live in the desert, should find their counterparts in the Trias, if arid conditions existed during their formation.

REVIEWS.

I.—Rock Minerals. By Professor Joseph P. Iddings. (New York: Wiley & Sons, 1906.)

DURING the last ten years so many advances have been made in the microscopic study of minerals, and so many new species have been recognised among the minerals of rocks, that the need for a new textbook of the subject in the English language has been much felt. Professor Iddings' book is in some ways not unlike the well-known Rosenbusch Iddings', which has served the needs of several generations of students. It is really, however, a new work, as a very excellent introductory or general part has been provided in which the chemical, physical, and optical properties of minerals are described, while the second or descriptive part is entirely remodelled and brought up to date. It is not difficult to trace the influence of certain standard authors in the treatment of some parts of the subject; more especially that of Professor Groth in the chapters on optical properties, and of Professor Rosenbusch in the special descriptions of the minerals. But the book has a marked individuality owing to the bright and interesting manner in which the author has handled his materials. It is brief,

[1] Geological Journal, 1903.

but no doubt contains enough for the student's requirements. To say that it is the best work in the English language on this subject is unnecessary; it compares very favourably with any of the French or German manuals in current use. It will not obviate the use of the larger treatises, such as Rosenbusch-Wülfing, but will serve as an admirable introduction to them, and should find a place among the working manuals of every student of petrology.

Very few inaccuracies have come to our notice in reading the book. We may point out, however, that the Canada balsam on which rock slides are mounted has by no means a constant refractive index of 1·539; it varies somewhat, and is often 1·542 to 1·544, and this is of some importance in determining felspars, nepheline, etc. The student should be warned to test it for himself in slides containing quartz. The use of the selenite plate in determining the sign of axes and bisectrices of biaxial crystals should be given; it is much to be preferred to a mica plate, and is one of the most useful accessories to a petrological microscope. Some description of the method of measuring optic axial angles should certainly be provided; nowadays by means of a Schwartzmann's scale this is a very simple operation. Professor Iddings makes the very useful suggestion that the capital letters X, Y, and Z should be used to designate the three principal axes of the triaxial ellipsoid. We hope it will be generally adopted, as it will save a great deal of trouble in correcting printers' proofs.

In the tables at the end of the book the minerals are classed as isotropic, uniaxial, and biaxial, and given in groups arranged according to their refractive indices, a method which has many advantages to recommend it. The excellent coloured plate of interference colours, originally prepared by Lévy and Lacroix, is reproduced and will be greatly appreciated both by teachers and students.

II.—Rocks of the Cape Colville Peninsula, New Zealand. By Professor Sollas, with introduction and descriptive notes by Alexander McKay, F.G.S.

THE Cape Colville Peninsula is part of the well-known Hauraki mining district, the source of large quantities of gold within the last forty years. It contains a great variety of igneous rocks, many of which are in advanced stages of decomposition and solfataric alteration. Many names had been applied to them by the miners, and it seemed necessary to get an authoritative classification; for that purpose about four hundred specimens were sent to Professor Sollas, who has written brief descriptions of them. A general account of the region is provided by Mr. McKay, who has apparently acted as editor of the volume. It is the first effort to treat of the petrography of this area as a whole. The book is illustrated by a large number of whole-page photomicrographs, which, while they are not all of equal excellence, often give a very clear idea of the structure of the rocks which are under description.

Volcanic action has gone on in this district in Palæozoic (Devonian and Carboniferous) and in Tertiary times. The igneous rocks are principally andesites of various types, dacites, rhyolites, and obsidians,

but no well-characterised trachytes or basalts are present, though olivine occurs in some of the Tertiary andesites. Many of the andesites have a groundmass which appears to be pilotaxitic, but Professor Sollas has found that there is always in these rocks a matrix of quartz; the structure is really micropoikilitic. His observations on the isotropic material which replaces the felspar phenocrysts in certain modes of decomposition are very interesting. They had previously been described as fused or vitrified felspars. Many of the rocks are filled with secondary quartz or opal, sericite, and chlorite; in others there is much tridymite. Some of the andesites show fluxion brecciation; that which has been described as Wilsonite is probably of this nature, and in another case we have a hornblende hypersthene andesite in which the phenocrysts have been broken up and seem mylonised before the matrix had completely solidified. Another very interesting group of rocks is the spherulitic rhyolites of this region; some of them are well known to contain large spherulites with branching or 'cervicorn' processes, and excellent figures of these wonderful structures are given in these two volumes.

III.—Geology of the Federated Malay States.

Geologist's Report of Progress. September, 1903–January, 1907. With rough sketch-map (topographical). By J. B. Scrivenor, Geologist F.M.S., formerly of H.M. Geological Survey of Great Britain. 8vo; pp. vi, 44. Printed at the F.M.S. Government Press, Kuala Lumpur. 1907. Price one dollar.

THE Government of the Federated Malay States are to be congratulated on having requisitioned the services of so capable and energetic an officer as Mr. J. B. Scrivenor to unravel the many intricate problems connected with the geological structure of that country. The geologist's work in these regions has been carried out under great difficulties, both on account of the want of good, serviceable topographical maps and because of the dense jungle which covers the country at high altitudes: nevertheless, the author gives us an excellent account of his three years' explorations. Some of the items of information have already appeared in "The Progress Report" for 1904, a notice of which has been published in the Geological Magazine for 1906, pp. 40, 41, in association with another of the author's reports, "On the Geology of the Residency of Sarawak," etc.

The present Report is divided into two sections, viz. 'Structural' and 'Economical.' Under the former is described 'the Chert Series,' 'the Raub Series,' and 'the Tembeling Series.' The first of these, occurring at Tras, Raub, Lubok Plang, etc., contains Radiolaria, and may be analogous to the Culm of Devonshire or Sumatra; the next has yielded Carboniferous Cephalopods at Mill Gully and Goa, which have been determined by Mr. G. C. Crick, and remnants of a Permian fauna at Lubok Sukum, which favours correlation with the Upper *Productus*-limestone of the Salt Range, India; whilst the Tembeling Series is made to include a number of Triassic shells from Kuala Lipis, described some years since by Mr. R. Bullen Newton,[1] and

[1] See Geol. Mag., 1901, pp. 128, 189.

INDIA.		PAHANG. (*Federated Malay States.*)		MALAY ARCHIPELAGO.
UPPER GONDWANA.	*Jurassic.*	GRANITE with basic dykes.	*Jurassic.*	MIDDLE OOLITE OF SARAWAK. (*Limestone and marl.*) DOGGER OF W. BORNEO. (*Sandstone with some marl and limestone.*) LIAS OF W. BORNEO. (*Marl and clay slate with fine sandy beds.*)
	Trias.	TEMBELING SERIES. Conglomerate with pebbles of chert of the 'Chert Series,' sandstone, red and grey shales.	*Trias.*	ROTTI. W. BORNEO. *Clay slate, rarely calcareous, sandstone, banded, clouded and spotted siliceous beds, with Radiolaria.*
PRODUCTUS BEDS OF THE SALT RANGE.	*Permian.*	PAHANG VOLCANIC SERIES. RAUB SERIES. Limestone, marl, calcareous shale, shale.	*Permian.*	TIMOR. *Limestone.* ROTTI. *Limestone.* *Supposed Paleozoic of W. Borneo.*
	Carboniferous.	CHERT SERIES. Chert, with Radiolaria, light-coloured siliceous shale, carbonaceous shale with Radiolaria and abundant pyrite.	*Carboniferous.*	TIMOR (*Sandy Limestone.* ROTTI) PADANG HIGHLANDS, W. SUMATRA. *Fusulina Limestone.* CULM OF SUMATRA?.

fragments of a recently discovered fish which, according to Dr. A. S. Woodward, resembles *Semionotus*, a characteristic genus of the Trias formation. In the same series the author also places those interesting Phyllopod remains (*Estheriella*) which he obtained from the Semanggol Range, and which have been described by Professor T. Rupert Jones,[1] F.R.S., as of Trias age. Reference is also made to the author's discovery of fossils at Singapore, which were described by Mr. R. B. Newton and regarded by him as belonging to probably a Middle Jurassic horizon.[2] These particular fossils were found in an estuarine deposit, and consisted of marine mollusca (*Goniomya*, etc.) associated with plant-remains (*Podozamites*), an assemblage of forms resembling a facies peculiar to the Upper Gondwana Beds of India and other Eastern countries. Without actually placing the Singapore deposits in the Tembeling Series, the author acknowledges a similarity of structure with that group of beds.

The author then considers the mutual relations of the 'Chert,' 'Raub,' and 'Tembeling Series,' the chief points of which are set out in a table giving the probable equivalents of these deposits in India and various parts of the Malay Archipelago. So important is this table considered as a first attempt to correlate the formations of this area that we have ventured to reproduce it on the present occasion (p. 566).

The 'Economic' part of the report deals chiefly with the gold-mining industry and tin-mining. Gold, according to the author, "is not confined to any one rock in the Federated Malay States; but it is interesting to note that the greater part of the underground operations have been conducted in rocks of the Raub Series, and igneous rocks associated with them." Both alluvial and lode gold occur in the F.M. States, although scarcely worth developing under present circumstances. Should the jungle be cleared it is possible that the gold industry might be more successful. A great amount of information is given on the tin-lodes, including their occurrence, geological features, etc.

Throughout the report the author gives numerous references to the literature consulted.

R. B. N.

IV.—A Geological Map of Armenia and its Border-Ranges, with Indications of Minerals and Mineral Springs. Drawn and hand-coloured by Felix Oswald, D.Sc., F.G.S. One sheet (36 × 25 ins.); scale, 16 miles to one inch (1 : 1,013,760). With Explanatory Notes, 16 pp. London (Nottingham printed), 1907: Dulau & Co. Price 25*s*. net.

DR. OSWALD'S "Geology of Armenia," which we noticed in these columns but a few months ago, is now out of print and unattainable. This is the map to accompany the volume, and the little pamphlet issued with it gives a brief sketch of the matter contained in detail in the larger work. The map contains the new and important surveys made by the author between Trebizond and

[1] Geol. Mag., 1905, pp. 49–52, Pl. II.
[2] Geol. Mag., 1906, pp. 487–496, Pl. XXV.

Lake Van, and includes the observations made by the following:—Abich, Ainsworth, Batsevich, Fournier, Frech, Hamilton, Koch, Loftus, Möller, Pohlig, Radde, Simonovich, Tchihatcheff, Tsulukidse, Wagner, and the 140 other persons mentioned by the author in his bibliography. The peaks and passes are indicated in the ranges, recent and extinct volcanoes, craters, mineral springs, whether hot or cold, and the minerals. The map is crowded with names, and ranges from the Caucasus on the north to the southern borders of Lake Urmi on the south, from the Euphrates on the west to the Caspian on the east. The coloration is well-done in transparent waterproof tints, and the production, in every way as remarkable as was the author's volume, will be of great value to geographers as well as to geologists.

C. D. S.

V.—Geological Survey of England and Wales.

The Geology of the Country around Hungerford and Newbury. By H. J. Osborne White, F.G.S. pp. 150. 1907. Price 2*s.* 6*d.*

THIS memoir is an explanation of Sheet 267 of the New Series of the Geological Maps on the scale of one inch to the mile. The district with which it deals is situated mainly in South-Western Berkshire, but includes a part of Wiltshire and a very little bit of Hampshire. The only important towns are Hungerford and Newbury.

The solid geology is very simple—Chalk for the most part and clays and sands of the Eocene to a small extent—but the district is agricultural, and to the farmer the Drift is often of as much importance as the solid geology. This is so in the present case, for Drift of one sort or another covers a large portion of the surface, as an inspection of the map will show. The account of the Drift, too, occupies a considerable part of the memoir.

The solid geology is illustrated by an excellent horizontal section engraved upon the map. It illustrates the relative position of the various beds down to and including the Gault. That formation does not, however, come to the surface here, nor does there seem to be any record of a well or of a boring which has passed through it in this district. The Upper Greensand is consequently the oldest formation dealt with, but does not present features of any special interest. The Chalk is the important formation of the district, since it is found either at the surface or underlying Drift or Eocene beds over almost the whole area. Mr. Osborne White estimates that in this part of the country the thickness of the Chalk when most fully developed is about 700 feet. This, he adds, is a thickness not unusual in the Southern Midlands, but much less than that attained near the south and east coasts, where measurements of 1,000 and 1,300 feet have been recorded.

On the map the Chalk is divided into Upper Chalk, described by Mr. White as typically soft and white and containing many flints, with an estimated thickness of 400 feet; Middle Chalk, white to greyish-white, harder and less flinty, with a thickness of 120 feet at one place where it could be measured; Lower Chalk, greyish and marly, without flints, 120 to 150 feet or more. It is interesting to compare

these figures with the record of the boring at Winkfield, near Windsor. There the thickness of the Chalk formation was found to be 725 feet, divided as follows: Upper Chalk, 337 feet; Middle Chalk, 169 feet; and Lower Chalk, 219 feet.[1]

The zones of the Chalk are not indicated upon the map, but they are fully dealt with in the memoir, and a sketch-map is given at p. 44 upon which the boundaries of the upper zones are marked. In Mr. Jukes-Browne's memoir on the Cretaceous Rocks of Britain, vol. iii, published in 1904, an account is given of the occurrence of the zones of *Marsupites* and of *Actinocamax quadratus* in the northern part of Hampshire (pp. 188–192), and, speaking of the latter zone, Mr. Jukes-Browne remarks that it appears to come in at certain places along the central part of the Chalk area between the anticlines of Winchester and Kingsclere. Probably, he adds, it only occurs in the form of outliers in the central part of the deeper synclinal troughs.

The present memoir deals with the district to the north of the Kingsclere anticline, and the author brings forward evidence tending to justify Mr. Jukes-Browne's inference, for he is able to record the occurrence of both the *Marsupites* and the *Actinocamax quadratus* zones, the latter in two places, in both cases in a shallow syncline. It should be added that much of this evidence had previously been published in a paper by Mr. Osborne White and Mr. Llewellyn Treacher, read before the Geological Society on April 25th, 1906 (Quart. Journ. Geol. Soc., vol. lxii, p. 499). Mr. White shows that the *Marsupites* zone, with its two sub-zones, the *Marsupites* band above and the *Uintacrinus* band below, is clearly recognisable in the Hungerford–Newbury district, but he states that the only places at which the zone is known to attain its full development at the outcrop are Kintbury, to the west of Newbury and Winterbourne, near Boxford, to the north-west of Newbury. He estimates the maximum thickness of the zone at 60 feet, i.e. about half that attained in East Kent and at Salisbury. The zone of *Actinocamax quadratus* has been recognised by the author in two small tracts, one on the spur of ground between Boxford and Winterbourne, and the other to the south of Kintbury. The thickness of the zone is 40 feet or more.

Mr. Osborne White devotes a chapter to the consideration of the structural relations of the Chalk and the Lower Eocene beds. The Eocene strata to the south of the River Kennet rest, as a rule, upon the Chalk of the *Marsupites* band, but are underlain by the *Actinocamax quadratus* beds near Kintbury, by the *Uintacrinus* beds to the south-west and south-east of Hungerford, and by the *Micraster cor-anguinum* chalk to the north-west of that town. North of the Kennet the Tertiaries are in contact with the *Uintacrinus* band over a small, irregular, and possibly discontinuous tract extending from the neighbourhood of Wickham south-eastwards at least as far as, and probably much farther than, Shaw, but lie directly upon some part of the upper half of the *Micraster cor-anguinum* beds everywhere else except in the little area west of Winterbourne, where the *Marsupites*

[1] J. H. Blake & W. Whitaker, "The Water Supply of Berkshire": Mem. Geol. Surv., 1902, p. 95.

and *Actinocamax quadratus* beds reappear in an outlier. Despite the occurrence of outlying patches of the *Act. quadratus* Chalk near Kintbury and Winterbourne, the tendency of the Eocene to overstep the higher zones of the Chalk towards the north is clearly recognisable. This northward overstep of the higher parts of the Chalk may, the author thinks, safely be attributed to an early Tertiary or pre-Tertiary planation, after the Chalk had received a gentle tilt approximately towards the south, and he considers that the northward overstep of the higher zones of the Chalk by the Eocene formation, which he has shown to exist in this district, is not merely a local phenomenon, but part of the transgression which cuts out the *Belemnitella mucronata* zone to the north of Salisbury and the greater part of the *Actinocamax quadratus* zone somewhere between that place and the crest of the Sydmonton range.

From the evidence before him the author infers that at or a little after the close of the Cretaceous period the tract, now the western half of the London Basin, formed part of the northern slope of an area of relative depression whose centre or axis lay far to the south, possibly on the site of the English Channel, and that before the deposition of the earliest Eocene sediments so far recognised in this region, the gently-inclined Chalk was subjected to a planation which bevelled off its higher zones in descending order towards the north, leaving here and there a troughed outlier such as that at Kintbury. The Eocene beds thus rest upon an eroded surface of Chalk, and the author considers that, at least, the ultimate shaping of this platform was the work of the sea. He describes the junction as even, or at most but slightly undulating, except, of course, where the Chalk has been indented by piping in more recent times. The top of the Chalk is often penetrated by tubular borings filled by material similar to that of the Eocene bottom bed. Similar borings in the top of the Chalk have been recorded in the adjoining districts, and have been variously referred to boring molluscs and to the roots of marine plants.[1]

The bottom bed of the Eocene consists of a few feet of dark-green or speckled greyish-green glauconitic loamy sand interbedded with seams of grey, greenish, or brown clay, often roughly laminated. Slightly worn or pitted flint nodules, with green coats and pebbles, and subangular chips of flint with the same external coloration are almost invariably present at the base, the nodules usually appearing in section as a single row at, or a few inches above, the top of the Chalk. Concretions of iron oxide, small granular aggregates of 'race,' and fine seams of chalky material are not uncommon in the same position, and in some places these and derived chalk fossils are abundant.

It is, we think, usually believed that the green-coated flints so frequently found at the bottom of Eocene beds where they rest upon Chalk are a part of the insoluble residue left by the underground

[1] See W. Whitaker, "Geology of the London Basin": Mem. Geol. Surv. (1872), p. 100. W. H. Hudleston, "Excursion to Reading": Proc. Geol. Assoc., vol. iv (1876), p. 521.

decay of the top of the Chalk after the Eocene bed had been deposited, but whatever may be the case in other districts the evidence given above clearly shows that a different explanation of the presence of green-coated flints in the bottom bed is required here. The tubular borings in the surface of the Chalk and the chalky material in the bottom bed seem to show that no appreciable amount of dissolution of the Chalk surface has taken place since the deposition of the Eocene beds upon it.

Banks of closely packed oyster-shells form a striking feature of the bottom bed in not a few sections, and the author records teeth of *Lamna* and a few marine shells. He infers that the bottom bed was deposited under shallow-water marine conditions. As elsewhere, the Reading Beds above the marine bottom bed consist of sands and mottled clays without shells, but leaf impressions have been observed at two places. They occur in seams of clay closely overlying the bottom bed, i.e. in a similar position to the Reading Leaf-bed. Mr. Starkie Gardner believed the mottled clays of the Reading Series to be a fresh-water deposit (Quart. Journ. Geol. Soc., vol. xxxix, p. 210), and we may probably regard all the beds in this district between the bottom bed of the Reading Series and the basement bed of the London Clay as of fresh-water origin.

The London Clay, as has long been known, thins westwards, and at the outlier west of Bedwyns in the south-western corner of the district it is stated to be only about 15 feet thick, whilst at Chisbury Camp at the northern end of the outlier there seems to be nothing between the Bagshot Beds and the Reading Series. Mr. Bennett thought that some greenish sand near Inkpen might belong to the Bracklesham Beds, but Mr. White gives reasons for doubting this, and consequently the highest Eocene formation in the district belongs to the sandy series, which in the London Basin intervenes between the London Clay and the Bracklesham. This formation is marked i^4 on the map, and is there termed "Bagshot Beds," whilst in the memoir it is described as "Lower Bagshot Beds." The similar beds at Bournemouth are on sheet 329 marked i^4, and termed "Bagshot Beds," whilst in Mr. Clement Reid's memoir on that sheet (1898) the formation is called "Bagshot Sands." We thus find the same formation with three different names, which seems needlessly to complicate matters.

After dealing with the Eocene formations, the author gives us a most interesting and original chapter upon the post-Bagshot disturbances and drainage features. At one time there was a fairly general idea that the sheets of gravel which cap the plateaux in the neighbourhood of the River Thames were a marine deposit, but in recent years the tendency amongst the workers in the geology of the South of England has been to look upon them as old river gravels, and the present author, Mr. Osborne White, considers that the drifts are local subaërial and fluviatile accumulations, which betray in their distribution a more or less obvious relation to, or dependence on, the larger (if not the smaller) elements of the existing physiography. As to the age of the drift deposits, he says that though some of them may be of Pliocene age, the bulk of them seem to belong to the Pleistocene and Recent periods, and many of them undoubtedly do so.

The beds of gravel of the district are separated upon the map into two divisions or classes—

(i) Plateau Gravel (of doubtful age and origin).
(ii) River and Valley Gravel.

Now, as the author explains, there may be some practical convenience in this division, though to a great extent it is a survival of the old theory of the marine origin of the plateau gravels. In any case, the result of the conclusion to which the author has come, and which has just been quoted, is that when he comes to speak of the plateau gravels he says: "The 'Plateau Gravel' group as defined on the sheet is, in a measure, an arbitrary one, for some of its members are not to be distinguished from deposits classed as 'River and Valley Gravel' by their composition, structure, mode of occurrence, or altitude, absolute or relative, that is to say, by any of the tests which are usually regarded as of chief importance for the discrimination of unfossiliferous, or very sparingly fossiliferous, drifts of this type, and further on he remarks that the Plateau and the Valley Gravels are very often inseparable; their more level spreads frequently appear to be but the higher and lower members of a single graduated series."

If it be admitted that the author is correct in his opinion, and we believe that he is here in agreement with many or most of his fellow-workers in the Thames district, then the history of our river system is thrown back to a vastly earlier date than could have been contemplated by those who looked upon the plateau gravels as of marine origin, and we find that the author is fully prepared to accept the result of his view, for he says that it seems not improbable that the broad outlines of the present drainage system were marked out in the Miocene period coincidently with the development of the Kingsclere fold. At the same time he considers it possible that the dominant surface slopes of the district, in so far as they have a tectonic origin, may be due less to Miocene folding than to Pliocene warping, and he also observes that the district may have been overflowed by the Diestian Sea, which, though not very probable, is no doubt a possibility for which we have to allow.

If we agree in the author's view as to the origin and antiquity of the gravels, the question of the age of the various deposits in relation to the age of the most recent earth-movements is one of great importance, for if earth-movement continued after the deposit of any part of the gravels the relative position and altitude of different gravel deposits may have been greatly affected thereby. The author, however, in suggesting a tentative grouping of the gravels, thinks it best to assume that the original height-relations of the sheets of gravel have not been significantly changed by differential earth-movements.

He separated the plateau gravel into three stages—

(i) Cold Ash Stage gravel, now 265 feet above the present River Kennet, and possibly of late Pliocene age.
(ii) Bucklebury Stage, now 230 feet above the present river, possibly belonging to the earlier part of the Pleistocene period.
(iii) Silchester or Greenham Stage, 150–160 feet above the modern river of rather later date.

These gravels are more or less sandy and often well stratified, and the author distinguishes from them some examples of a much more argillaceous type of deposit, which he suggests may be of the nature of a mud-flow, generated by rapid thawing of frozen soil at or about the time of maximum glaciation of the country further to the north.

In the chapter on the valley gravel the author records several finds of implements at different places. The celebrated Knowle Farm pit is situated near Savernake in the south-west corner of the district. The implements from it are distinguished by a very peculiar varnish-like glaze, and Mr. Clement Reid, who described the locality, considered it to be contemporaneous with the Palæolithic deposits of Southampton Water, Bournemouth, and the Avon Valley. (Summary of Progress of the Geol. Survey for 1902, p. 208, 1903.)

The Alluvium of the River Kennet, with its deposit of fossiliferous fresh-water marl, is of great interest, and a good account of it is given with lists of the fossils. It is further dealt with in a valuable note by Messrs. A. S. Kennard and B. B. Woodward, which is printed as an appendix to the memoir.

Dr. W. Pollard and Mr. H. H. Thomas contribute another appendix on insoluble matter in samples of Upper Chalk, and the memoir concludes with a bibliography and an index.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 6th, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R. S., President, in the Chair.

The following communications were read:—

1. "On a Collection of Fossil Plants from South Africa." By Professor Albert Charles Seward, M.A., F.R.S., F.G.S.

The material on which this paper is based was, for the most part, collected by members of the Geological Survey in Cape Colony from the Molteno and Burghersdorp Beds. The Molteno Beds are placed at the base of the Upper Karroo, or Stormberg Series; the Burghersdorp Beds constitute the uppermost strata of the Middle Karroo, or Beaufort Series. Mr. A. L. Du Toit, who has contributed accounts of the stratigraphy of the plant-bearing and associated rocks, describes the occurrence of a transitional zone between the Molteno and the Burghersdorp Beds. The following species are described:—

(A) Molteno Beds.

Schizoneura Carrerei, Zeill.
Schizoneura sp.
Thinnfeldia odontopteroides (Morr.).
Thinnfeldia sp.
Thinnfeldia, sp. nov.
Tæniopteris Carruthersi, Ten.-Woods.
Cladophlebis (Todites) Rœsserti (Presl).
Pterophyllum sp.
Baiera, sp. nov.

(B) Burghersdorp Beds.

Schizoneura sp.
Thinnfeldia, sp. nov.
Tæniopteris Carruthersi, Ten.-Woods.
Danæopsis Hughesii, Feist.
Odontopteris, sp. nov.
Strobilites, sp. nov.
Pterophyllum sp., cf. *Pt. Tietzii*, Schenk.
Stigmatodendron, sp. nov.

A description is also given of *Schizoneura africana*, Feistmantel, a species originally figured by Hooker in an appendix to Bain's paper, published in 1845.

The additional plants recorded from the Molteno Beds afford further evidence in favour of assigning this member of the Stormberg Series to the Rhætic Period. While possessing certain Rhætic species, the Burghersdorp flora as a whole indicates a somewhat lower horizon.

2. "Permo-Carboniferous Plants from Vereeniging (South Africa)." By Professor Albert Charles Seward, M.A., F.R.S., F.G.S., and Thomas Nicholas Leslie, F.G.S.

The majority of the specimens described in this paper were obtained by Mr. Leslie from a sandstone quarry 1½ miles from Vereeniging, on the banks of the Klip River; the sandstones are associated with shales, coal-seams, and glacial conglomerates. In the opinion of the authors, the plant-beds should be included in the Ecca Series (Lower Karroo). While recognizing certain well-marked differences between the *Glossopteris* floras and the Upper Carboniferous and Permian floras of the Northern hemisphere, they are inclined to think that there are more types common to the two botanical provinces than is generally supposed.

The following species have been recognized at Vereeniging:—

Schizoneura sp.
**Glossopteris angustifolia*, Brongn., var. nov.
Glossopteris angustifolia, Brongn.
Glossopteris Browniana, Brongn.
Glossopteris indica, Schimp.
Glossopteris sp., cf. *Gl. retifera*, Feist.
Gangamopteris cyclopteroides, Feist.
**Callipteridium* sp.
Neuropteridium validum, Feist.
Bothrodendron Leslii, Sew.
**Lepidodendron*, sp. nov.
**Lepidodendron Pedroanum* (Carr.).
Sigillaria Brardi, Brongn.
Psygmophyllum Kidstoni, Sew.
Cordaites (*Nœggerathiopsis*) *Hislopi* (Bunb.).
Conites, sp.

Those marked with an asterisk are recorded for the first time.

3. "On the Structure and Relations of the Laurentian System of Canada." By Professor Frank Dawson Adams, D.Sc., F.R.S., F.G.S.[1]

This paper contains an outline of the results of the examination by Dr. Barlow and the author of an area of 4,200 square miles, comprised within the Haliburton and Bancroft sheets of the Ontario and Quebec series of maps. The paper opens with a short account of Logan's work in the original Laurentian area. The main conclusions reached by the author may be thus summarized:—(1) The Laurentian System of Sir William Logan consists of a very ancient series of sedimentary strata, largely limestones, invaded by great volumes of granite in the form of bathyliths; (2) this sedimentary series is one of the most important developments of the pre-Cambrian rocks in North America, it presents the greatest body of pre-Cambrian limestones on the continent, and it is best designated as the Grenville Series; (3) the invading masses of granite are of enormous extent; they possess a more or less distinct gneissose structure, due to the movements of the magma, which developed a fluidal and, in the later stages of intrusion, a protoclastic structure in the rock; (4) the granite gneiss of the bathyliths not only arched up the invaded strata into

[1] Communicated by permission of the Director of the Geological Survey of Canada.

a series of domes, but 'stoped' out portions of the sides and lower surface of the arches, the fragments torn off from walls and roof by the invading granite being found scattered throughout the mass of the invading rock; this 'stoping,' however, probably developed only a small part of the space which the granite now occupies; (5) the invading granite not only exerted a mechanical action upon the invaded strata, but also gave rise to a variety of metamorphic products, among others amphibolite produced by its action in the limestone, which accounts for the fact that while the invaded strata are chiefly limestone, the fragments of the latter, where found in the granite, consist of amphibolite; (6) the invading bathyliths and allied intrusions of granite occupy the greater part of the great Northern Protaxis of Canada, which has an area of approximately 2,000,000 square miles. It has, therefore, been considered advisable to restrict the name Laurentian to this great development of the 'Fundamental Gneiss,' which, although intrusive into the Grenville Series, nevertheless underlies and supports it; (7) the relation of the Grenville Series, which forms the base of the sedimentary portion of the geological column in Eastern Canada, to the Huronian and Keewatin Series, which are the oldest stratified rocks in the western part of the Protaxis, has yet to be determined, the two not having so far been found in contact; nowhere, moreover, either east or west, has the original basement on which the first sediments were laid down been discovered; these are everywhere torn to pieces by the granite intrusions of the Laurentian.

At 8 p.m. on Wednesday, November 13th, the actual anniversary of the foundation of the Society in 1807, the Fellows met informally, to the number of about 100, at the Society's Rooms in Burlington House, where the various addresses presented on September 26th were on view.

"The History of the Geological Society of London," by Horace B. Woodward, F.R.S., illustrated with twenty-eight portraits and reproductions of medals, is now obtainable at the Society's Apartments, price 7*s.* 6*d.* nett; and at the reduced price of 6*s.* by Fellows only.

CORRESPONDENCE.

RE CONE-IN-CONE.

Sir,—Touching the origin and age of this formation or structure, would such of your readers as have made observations in this connection kindly tell us at *what depths* below the present surface they have discovered or noted this rock-structure? We know that the Coal-measures contain it, but at what depth in pits (shafts, boreholes, or underground workings) has it been found? Reports state that it occurs in the Cambrian, Lower Silurian, Devonian, as well as in comparatively recent epochs, but the point is: is it as *old* as the strata enclosing it? (See vol. 188, 1894, etc.) W. S. Gresley.

Duffield, Derby.
13*th Nov.*, 1907.

THE ZONES OF THE CHALK.

SIR,—In June last you kindly inserted a notice on the discovery of *Uintacrinus* Chalk in the neighbourhood of Orpington, Kent. Following up my researches, I am pleased to say I have been successful in tracing this zone and the succeeding one of *Marsupites* in Holwood Park, Keston, the residence of Lord Derby; and a few weeks ago, in an overgrown pit at Fox Lane, Keston, I discovered the junction bed of the *Micraster cor-anguinum* and *Uintacrinus* Chalk.

I hope ere long to give the results of further work in this area and the fauna obtained therefrom. G. E. DIBLEY.

SYDENHAM, S.E.
November 18th, 1907.

OBITUARY.

SIR JAMES HECTOR, K.C.M.G., M.D., F.R.S., F.L.S., F.G.S.

BORN 1834. DIED NOVEMBER, 1907.

WE regret to record the death of Sir James Hector, late Director of the Geological Survey of New Zealand and Chancellor of the University of New Zealand. Born in Edinburgh in 1834, he was educated at the University in that city, and took the degree of M.D. in 1856. In the following year he was chosen, through the influence of Sir Roderick Murchison, as surgeon, geologist, and naturalist to accompany Captain John Palliser's exploring expedition to the central parts of British North America. He then made important ethnological and geographical observations, discovered the pass by which the Canadian Pacific Railway now crosses the Rocky Mountains, and afterwards published an important paper on the geology of Lake Superior. In 1861, by Murchison's recommendation, he was appointed geologist to the Provincial Government of Otago, New Zealand, and thenceforth devoted his energies to that country. He became Director of the Geological Survey in 1865, and held the post until 1903. He was elected a Fellow of the Royal Society in 1866, and was created K.C.M.G. in 1887. As a geologist his principal works include Reports on the Coal Deposits, on the Geology of Otago and other parts of New Zealand, and a geological sketch-map of the Islands. The volcanic phenomena and thermal springs, the fossil birds and reptiles, and the recent zoology and botany of New Zealand likewise engaged his attention. He was awarded the Lyell Medal by the Council of the Geological Society in 1877.

MISCELLANEOUS.

THE GEOLOGICAL COLLECTION OF THE LATE JOHN FRANCIS WALKER, M.A., F.L.S., F.I.C., F.C.S., F.G.S.—Having regard to the great value of Mr. J. F. Walker's collection of Brachiopoda and its importance to men of science, Mrs. Walker and her son, Mr. Gelson Walker, have decided to present it to the Trustees of the British Museum. (See obituary in August Number, p. 380.)

INDEX.

ACT

ACTINOCAMAX from English Chalk, Two Rare Forms of, 389.
Actinocamax Blackmorei, G. C. Crick, sp. nov., 389.
Adams, Professor F. D., The Laurentian System of Canada, 574.
Africa, South, Bokkeveld Fossils from, 34.
Age of Niagara Falls, Professor J. W. Spencer on, 285.
Alabama, Geological Survey of, 373.
Amaltheus spinatus Zone and Middle Lias, Leicestershire, 462.
Anatifopsis balclatchiensis, F. R. C. Reed, sp. nov., 109.
Andrews, C. W., Vertebrate Remains, Fayûm, Egypt, 97; Cervical Vertebra of *Zeuglodon*, Barton Clay, Hants, 179; Osteology of *Ophthalmosaurus icenicus*, Seeley, 202.
Anglesey, N.E., Glaciation and Physiography in, 348.
Animalium Index, by C. Davies Sherborn, Report on, 509.
Anthracomartus trilobitus, Scudder, Coal-measures, Sparth, near Rochdale, 546, 548.
Arber, E. A. Newell, Fossil Plants from Carboniferous Limestone, Chepstow, 4.
Arenig Rocks in West of Ireland, 84.
Armenia and its Borders, Geological Map of, 567.
Arnold-Bemrose, H. H., Toadstones of Derbyshire, 284.
Arrhenius' Theory of the Physical Causes of Vulcanicity, 173.
Arthropoda from British Coal-measures, Rochdale, Lancashire, 539.
Ashgillian Series, 59, 140, 536.
Australian Artesian Waters, 477.
Australian Geology, in Stanford's Geography, 1907, 423.
Australian Palæontologists on Silurian Ophiurids, 313, 479, 523.
Ayrton, Mrs., Marine Ripple-mark, 191, 287.

BRT

BALLYCASTLE Coalfield, Co. Antrim, 85.
Baron, Rev. Richard, Obituary of, 527.
Barry, Sir Francis Tress, Obituary of, 192.
Bather, F. A., Australian Palæontologists on Silurian Ophiurids, 313; on Nathorst's use of Collodion Imprints for Fossil Plants, 437; Nomenclature of Australian Silurian Ophiurids, 523.
"Beagle" Collection, Rocks of, 100.
Bedford, Clay Beds, by the Ouse, 24.
Bellinurus Baldwini, H. Woodw., sp. nov., 540; and *B. longicaudatus*, H. Woodw., sp. nov., M. Coal-measures, Rochdale, Lancashire, 541.
Bennett, F. J., Ightham, the story of a Kentish Village, 234.
Bennett, F. W., Felsites of Charnwood Forest, 470.
Bernese Oberland, Geology of, 43.
Berry, E. W., on Fossil Plants, 42.
Best, Edward, of the Geological Survey, Obituary Notice, 140.
Bicavea rotaeformis, Gregory, sp. nov., 442.
Birley, Caroline, Obituary Notice, 143.
Blackheath, Geological Note on, 211.
Bokkeveld Beds, S. Africa, Fauna of, 165, 222; Fossils, S. Africa, 34.
Bolton, H., Marine Fauna in Basement Beds, Bristol Coalfield, 333; Strontia Boulders in Trias, 471.
Bonney, T. G., Southern Origin of Northern Zone in Savoy and Swiss Alps, 237; "Sermons in Stones," 432.
Bosworth, T. O., Origin of Upper Keuper in Leicestershire, 460.
Brachiopod Morphology, S. S. Buckman on, 334.
Brachyurous Crustacean in *Clypeus*-Grit of Cotteswold, 79.
British Association, Leicester, Address to Geological Section, 409, 451; List of Geological Papers read before, 418.
British Trias, Origin of, compared with existing Deserts, 554.

BRÖ

Brögger, W. C., Zones of Neolithic Times, 282.
Brough, B. H., Iron Ore Supplies, 448.
Bryozoa, Rotiform, of the Chalk, 442.
Buckman, S. S., Brachiopod Morphology, 334.

CADELL, H. M., Plant-remains in Olivine Basalt, Baruss Coalfield, 219.
Calcareous Nodules, 334.
Canada, Geological Survey, Annual Report, 1901, 89.
Cantrill, T. C., Stratigraphical Note, Haverfordwest, 537.
Cape Colville Peninsula, N.Z., Rocks of, 564.
Carbonate of lime segregated to form nodules, 555.
Carboniferous Limestone, Chepstow, Fossil Plants from, 4; Faunal Succession in the, 70; Anglesey, 238.
Carruthers, R. G., & H. B. Muff, Arenig Rocks in West of Ireland, 84.
Centenary of Geological Society of London, 385, 522.
Century of Geology, A, 1807–1907, The Geological Society of London, 1.
Cephalopods of Cretaceous Rocks of Natal and Zululand, 339.
Cephalopods, Silurian, in the New York State Museum, 45.
Cervical Vertebra of *Xenicodon*, Barton Clay, Hants, 179.
Chalk, A Case of Metamorphism of, 145.
Chalk and its Dislocation, North Norfolk Geology, 268, 304.
Changes of Physical Constants in Minerals and Igneous Rocks passing from Crystalline to Glassy State, 188.
Chapman, F., Calcareous Nodules, 334; Nomenclature of Australian Silurian Ophiurids, 479.
Charleston Earthquake, 1886, 197.
Charnwood Forest, N.W. District of, 420.
Chemical Composition of Igneous Rocks, 171.
Chemical Reactions between Solids, 379.
Chubb, E. C., & F. P. Mennell, Fossil Mammalia found with Stone Implements, S. Africa, 443.
Clathropteris egyptiaca, A. C. Seward, sp. nov., 253.
Clay Beds by the Ouse, Bedford, 24.
Clayden, A. W., History of Devonshire Scenery, 360.
'Coal-Balls,' Relation of Concretionary Nodules of the Yarra to, 106.

DES

Coalfield, Ballycastle, Co. Antrim, 85.
Coal-measures, Arthropoda from Sparth, Rochdale, 539.
Coal-measures, Ilkeston, Two new species of *Eurypterus* from, 277.
Coastal Features, Co. Waterford, Ireland, 17, 501, 549.
Cole, Grenville A. J., Ballycastle Coalfield, 85.
Collodion as a Preservative for Fossils, 524.
Collodion Imprints of Fossils, Nathorst's use of, 437.
Comparative Fertility of the Soil above certain Geological Formations, 132.
Concretionary Nodules of the Yarra, relation to 'Coal Balls,' 106.
Cone-in-Cone, 575.
Conodonts in Coal-measures, 239.
Constitution of Interior of the Earth revealed by Earthquakes, 376.
Coral Rocks, Barbados, 238.
Corstorphine, G. S., Geological Aspects of South African Scenery, 352.
Cretaceous Formation, Bahia, Brazil, and its Vertebrate Fossils, 93.
Cretaceous, Upper, Fish-remains from Brazil, 193.
Cretaceous Polyzoa (Family Idmoniidæ), A Tabular View of, 122.
Cretaceous Rocks of Natal and Zululand, and Cephalopods of, 339.
Crick, G. C., Cretaceous Rocks of Natal and Zululand, and Cephalopods of, 339; Two Rare Forms of *Actinocamax* from English Chalk, 389.
Crook, T., Titaniferous Volcanic Rocks, 157.
Crustacea from Girvan, Sedgwick Museum Notes, 108.
Crystalline Rocks of Kukuruku Hills, Southern Nigeria, 92.
Crystalline Schists, 328.

DAVIES, A. M., Kimmeridge and Corallian of Brill, Bucks, 46; Collodion as a Preservative for Fossils, 524.
Davison, C., Swans a Earthquake, June 27, 1906, 377; Ochil Earthquakes of September, 1900, to April, 1907, 378.
Deeley, R. M., The Structure of Glacier Ice, 529.
Deformation and Variation in Sea-level, 115.
Desert Conditions and Origin of British Trias, by J. Lomas, 511, 554.
Desert Features, by H. T. Ferrar, 459.

DEV

Devonshire Scenery, History of, 360.
Dibley, G. E., *Cuttacrinus* in London Basin, 288, 576; Zones of the Chalk, 576.
Diprotodon australis, British Museum, A Reconstructed Skeleton of, 337.
Discovery of Marsupial Plates in *Pygocephalus*, 400.
Dolomites, Overthrust Structure in, 408.
Dorman, S. S., Volcanoes of Basutoland, 463.
Dorset Field Club, Proceedings of, 432.
Dorset Natural History and Antiquarian Field Club, 374.
Douglas, J. A., Changes of Physical Constants in Minerals and Igneous Rocks passing from Crystalline to Glassy State, 188.
Drift Deposits at Kirmington, Lincolnshire, 37, 471.
Du Toit, A. L., Pipe-Amygdaloids, Cape Colony, 13.

EARTHQUAKE, Charleston, 1886, 197.
Egypt, Fossil Plants from, 253.
Eminent Living Geologists: Sir A. Geikie, 1; William Whitaker, 49; Professor H. G. Seeley, 241.
Eoscorpius (Mazonia) Woodwardyi, H. Woodw., sp. nov., M. Coal-measures, Rochdale, Lancashire, 543.
Etheridge, R., Palæontology of South Australia, 474.
European Animals: Geological History and Distribution, 366.
Eurypterus from the Coal-measures, Ilkeston, 277.
Eurypterus Derbiensis, H. Woodw., sp. nov., 281.
Eurypterus Meyseyi, H. Woodw., sp. nov., 279.
Evans, O. H., Raised Beaches, Taltal, N. Chile, 48.
Evolution of *Stomatopora*, 20.

FAUNA of the Bokkeveld Beds, South Africa, 165, 222.
Faunal Succession in Carboniferous Limestone, Westmoreland, 70; S. W. England, 465.
Fayûm, Egypt, Vertebrate Remains from, 97.
Fearnsides, W. G., Lower Ordovician Succession in Scandinavia, 186, 257, 295; Pisolitic Iron-ores of Wales, 422.
Felsites of Charnwood Forest, 470.
Ferrar, H. T., Some Desert Features, 459.

GEO

Fertility of the Soil above certain Geological Formations, Comparative, 132.
Fish-remains from Brazil, Upper Cretaceous, 193.
Fisher, Rev. O., Land-Ice, 48.
Flora of Inferior Oolite of Brora, Sutherland, 370.
Formaght Strand, Co. Waterford, Coast Features, 17.
Fossil Footprints in Secondary Rocks, 239.
Fossil Mammalia associated with Stone Implements, S. Africa, 443.
Fossil Plants, E. W. Berry, 42; from the Carboniferous Limestone, Chepstow, 4; from S. Africa, 481, 573.
Fossiliferous Drift Deposits, Kirmington, Lincolnshire, 37, 471; and Keuper, Bromsgrove, 28.
Fox-Strangways, C., Geology of Leicestershire, 420.

GARWOOD, E. J., Faunal Succession in the Carboniferous Limestone, 70.
Geikie, Sir Archibald, K.C.B., 1, 432.
Geological Age of Shales of Parys Mountain, Anglesey, 148.
Geological Aspects of S. African Scenery, 352.
Geological Conditions of successful Artesian Boring at Lincoln, 47.
Geological Information about Blackheath, 211.
Geological Map of Ireland, 43.
Geological Society of London, 46, 47, 91, 93, 138, 179, 180, 186, 188, 237, 284, 330, 331, 333, 374, 573.
Geological Society of London: A Century of Geology, by Horace B. Woodward, 1, 385, 575.
Geological Society of London, Centenary of, 385.
Geological Survey of Canada, Annual Report, 1901, 89.
Geological Survey of England: Geology of Hungerford and Newbury, 568.
Geological Survey: Maps and Memoirs, Falmouth, Truro, Camborne, and Redruth, 1906, 175.
Geological Survey Memoirs: Macclesfield, Congleton, etc. (Sheet 110), 39; Wellington and Chard, 1906, 177; Geology of the South Wales Coalfield, 371, 514; Geology of Islay, 476; Country around Swansea, 514; Geology of Leicestershire and S. Derby Coalfield, 516; Geology of Lands End District, 517.

GEO

Geological Survey: Summary of Progress of 1905, 41; Dritt Maps, 178; Ireland, Memoir and Map, 232; India Report, 1906, 359; of Western Australia, 44; Scotland, New Maps, 1907, 283, 521.
Geologists' Report on Federated Malay States, 565.
Geology of Devonshire, by W. A. E. Ussher, 362.
Geology of India, "The Imperial Gazetteer of India," 1907, 319.
Geology of Oban Hills, S. Nigeria, 92.
Geology of Zambesi Basin, Batoka Gorge, Rhodesia, 138.
Geralaspura (?) *Sutcliffei*, H. Woodw., sp. nov., M. Coal-measures, Sparth, Rochdale, 545.
Gimson, M., & W. Keay, Keuper Marls, etc., Bardon Hill, 461.
Glacial Gravels, Holderness, 468.
Glacial History of Nantucket and Cape Cod, 137.
Glaciation and Physiography in N.E. Anglesey, 348.
Glacier Ice, Structure of, R. M. Deeley on, 529.
Gordon, M. M. Ogilvie, Overthrust Structure in the Dolomites, 408.
Gough, Prof. Geo. C., A Case of Metamorphism of Chalk, 145.
Greenly, E., Sandstone Pipes in Carboniferous Limestone, Anglesey, 238; Glaciation and Physiography in N.E. Anglesey, 348; Chemical Reactions between Solids, 379.
Gregory, J. W., Address to Geological Section, British Association, 409, 451; Australian Geology in Stanford's Geography, 423; Rotiform Bryozoa of the Chalk, *Bicavea rotiformis*, sp. nov., 442.
Gresley, W. S., on 'Cone-in-Cone,' 575.
Griesbach, Carl Ludwig, Obituary of, 240.
Grubenmann, Dr. U., Crystalline Schists, 328.
Guernsey, Northern, Rocks of, 74.

HARKER, Alfred, Rocks of the "Beagle" Collection, 100.
Harmer, F. W., Origin of Cañon-like Valleys and Lake-like areas of Depression, 331.
Harrison, J. B., Coral Rocks, Barbados, 238.
Haverfordwest, Base of Silurian near, 535, 537.

INF

Hector, Sir James, Obituary of (1834–1907), 576.
Henslow, G., Xerophytic Character of Coal Plants, 330.
Hickling, G., 'Overfolds' in Relation to Larger Folds, 506.
Hitchcock, C. H., Fossil Footprints in Secondary Rocks, 239.
Hobbs, Professor W. H., Charleston Earthquake, 1886, 197.
Hobson, Bernard, Volcanoes of Nevado de Toluca and Jorullo, Mexico, 5.
Hobson, B., & M. M. Solórzano, Plant-remains in Basalt, Mexico, 217.
Holderness, Glacial Gravels of, 468.
Holland, T. H., Geological Survey, India, Report, 1906, 359.
Holmes, T. V., Recent Geological Information about Blackheath, 241.
Honours to Men of Science, 432.
Hooley, R., Skull and part of Skeleton of *Goniopholis crassidens*, Wealden, Atherfield, Isle of Wight, 46.
Horwood, A. R., Palæontology of North Derby and Notts Coalfield, 421; *Amaltheus spinatus* Zone and Middle Lias, Leicestershire, 462.
Horwood, C. B., Pseudomorphous Pebbles of Pyrites, Crown Reef Mine, Witwatersrand, 187.
"How Long Ago" in Geology, 349.
Howorth, Sir H. H., North Norfolk Geology: The Chalk and its Dislocation, 268, 304.
Hull, E., Geological Conditions to Success of Artesian Boring, Lincoln, 47; Submergence of British Islands, 335.
Hungerford and Newbury, Geology of, 568.
Hunt, A. R., Marine Ripple-mark, 96; Mrs. Ayrton's Theory of Ripple-mark, 287; Saline Solutions and Ores, 525.

IDDINGS, Joseph P., Rock-minerals, 563.
Ightham: the Story of a Kentish Village, 234.
Igneous Rocks, Chemical Composition, 171.
Igneous Rocks to the S.E. of Dartmoor, 331.
Inclusions in Volcanic Rocks, 490.
Index Generum et Specierum Animalium, by C. Davies Sherborn, Report, 569.
India Geological Survey Report (1906), 359.
Inferior Oolite and Contiguous Deposits of Bath-Doulting District, 374.

INF

Inferior Oolite and Contiguous Deposits of Rissington and Burford District, 375.
Invertebrate Animals, Fossil, A Guide to British Museum, Natural History, 518.
Invertebrate Fauna of Uitenhage Series, Cape Colony, 289.
Iowa Geological Survey (1906), 373.
Ireland, Arenig Rocks in West of, 84.
Ireland, Geological Map of, 43.
Ireland, Geological Survey, Memoir and Map, 232.
Iron Ore Supplies, 448.

JOHNSON, J. P., Stone Implements of S. Africa, 372.
Joly, J., Radium in Rocks, 469.
Jorullo and other Volcanoes, noticed by B. Hobson, 5.
Jukes-Browne, A. J., Origin and Age of Plateaus around Torquay, 179; Hills and Valleys of Torquay, 360.

KARROO Beds, Cape Colony, and new Labyrinthodont (*Uytchosphecio-don Browni*), 433.
Karroo Beds, S. Africa, Fossil Plants, 573.
Keay, W., & M. Gimson, Keuper Marls, etc., Bardon Hill, 461.
Kentish Village, Ightham, The Story of a, 234.
Keuper, Origin of, in Leicestershire, 460.
Keuper at Bromsgrove, Fossiliferous, 28.
Keuper Marls, etc., Bardon Hill, 461.
Kimmeridge and Corallian of Brill (Bucks), 46.
Kitchin, F. L., Invertebrate Fauna of Uitenhage Series, Cape Colony, 289; A Correction, 480.
Knolls of Limestone, Craven, 36.

LABYRINTHODONT, Karroo Beds, Cape Colony, A New, 433.
Lacustrine Deposit at Hornsea, Post-Glacial, 138.
Lamplugh, G. W., Geology of Zambesi Basin, Batoka Gorge, Rhodesia, 138.
Land-Ice, Rev. O. Fisher, 48.
Lands End District, Geology of, 517.
Lang, W. D., Evolution of *Stomatopora*, 20; A Tabular View of Cretaceous Polyzoa (Family Idmonidæ), 122; The Selbornian of Stonebarrow, Charmouth, 150.
Lankester, Sir E. Ray, K.C.B., 132.

MOB

Laurentian System, The Structure and Relations of, 574.
Leeds, E. Thurlow, Notes on *Metrio-rhynchus superciliosus*, Desl., 314.
Leicestershire and S. Derbyshire Coal-field, Geology of, 420, 516.
Lichas (Homolichas) melnerbiensis, F. R. C. Reed, sp. nov., 396.
Life-Zones in Carboniferous Rocks, 465.
Limestone Knolls of Craven, 36.
Lomas, J., Marine Peat, Liverpool, 468; Deserts compared with British Trias, 511, 554.
Love, James, Comparative Fertility of the Soil above certain Geological Formations, 132.
Lowe, H. J., Igneous Rocks south-east of Dartmoor, 331.

MACCLESFIELD, Congleton, etc., Geology of, 39.
McKay, Alexander, & Professor W. J. Sollas, Rocks of Cape Colville, New Zealand, 564.
Maclaren, M., Australian Artesian Waters, 477.
Malay States, Federated, Geology of the, 565.
Marine Fauna in Basement Beds, Bristol Coalfield, 333.
Marine Peat, Liverpool, 468.
Marine Ripple-mark, 99, 191.
Marr, J. E., "Ashgillian Series," 59, 536.
Martin, E. A., "How Long Ago?" in Geology, 349.
Maryland Geological Survey, 1906, 372.
Matthew, Dr. W. D., Relationship of the Sparassodonts, 531.
Memoirs of Geological Survey, 39, 175, 177, 232, 369, 371, 476, 514, 516, 517, 521, 568.
Mennell, F. P., Somabula Diamond Field, 95.
Mennell, F. P., & E. C. Chubb, Fossil Mammalia with Stone Implements, S. Africa, 413.
Metamorphism of Chalk, A Case of, 145.
Metriorhynchus superciliosus, Desl., 311.
Mexico, Plant-remains in Basalt of, 217.
Middle Lias, Leicestershire, 462.
Mineralogical Society, London, 94, 189, 286, 378.
Mines and Minerals, "Indian Empire" (1907), 525.
Moberg, J. C., & C. O. Segerberg, Tremadocian Series, Sweden, 85.

MOJ

Mojsisovics von Mojsvar, Edmund, Death of, 527.
Muff, H. B., & R. G. Carruthers, Arenig Rocks in West of Ireland, 84.

NANTUCKET and Cape Cod, Glacial History of, 137.
Nathorst's use of Collodion Imprints for Fossil Plants, 437.
Nevado de Toluca and Jorullo, Mexico, Volcanoes of, 5.
New Dinosaur from Trias, Lossiemouth, Elgin, 93.
New York State Museum, Silurian Cephalopoda in, 45.
New Zealand, Rocks from Cape Colville, 564.
Newbury and Hungerford, Geology of, 568.
Niagara Falls, Recession of, 440.
Nomenclature of Australian Silurian Ophiurids, 479, 523.
Norfolk, North, Geology: The Chalk and its Dislocation, 268, 304.

OBITUARY: Sir Francis Tress Barry, 192; Rev. Richard Baron, 527; Edward Best, 140; Miss Caroline Birley, 143; Carl L. Griesbach, 240; Sir James Hector, 576; Professor E. Mojsisovics, 527; Professor Charles Stewart, 527; John Francis Walker, 288, 380; John Ward, 141.
Ochil Earthquakes of September, 1900, to April, 1907, 378.
Oldham, R. D., Constitution of Interior of Earth revealed by Earthquakes, 376.
Olivine Basalt, Bo'ness Coalfield, Plant-remains in, 219.
Ophthalmosaurus icenicus, Osteology of, 202.
Ordovician, Lower, Scandinavia, 186, 257, 295.
Ordovician System, Ashgillian Series, 59.
Origin and Age of Plateaus around Torquay, 179.
Origin of Cañon-like Valleys and Lake-like Areas of Depression, 331.
Osmundites Kolbei, A. C. Seward, sp. nov., 482.
Osteology of *Ophthalmosaurus icenicus*, 202.
Oswald, Felix, Geological Map of Armenia, etc., 567.
Overfolds in Relation to Larger Folds, 506.
Overthrust Structure in the Dolomites, 408.

REC

PALÆONTOGRAPHICAL Society, 190.
Palæontology, The Progress of, Pal. Soc., 1906, 134.
Palæontology of N. Derby and Notts Coalfield, 421.
Parkinson, J., Rocks of Northern Guernsey, 74; Post-Cretaceous Stratigraphy of S. Nigeria, 91; Crystalline Rocks of Kukuruku Hills, S. Nigeria, 92; Geology of Oban Hills, S. Nigeria, 92.
Parys Mountain, Anglesey, Geological Age of Shales of, 148.
Pearson, H. W., Deformation and Variation in Sea-level, 115.
Permo-Carboniferous Plants from South Africa, 481.
Phyllotheca Whaitsii, A. C. Seward, sp. nov., 481.
Primocaris curvata, F. R. C. Reed, sp. nov., 110.
Pipe-Amygdaloids, Cape Colony, 13.
Pisolitic Iron-ores of Wales, 422.
Plant-remains in Basalt, Mexico, 217.
Plant-remains in Olivine Basalt, Bo'ness Coalfield, 219.
Plants, Fossil, from S. Africa, 481, 573, 574.
Plants, Fossil, South Africa, from the Karroo, 573.
Plants from Egypt, Fossil, 253.
Polyzoa (Family Idmonidæ), A Tabular View of Cretaceous, 122.
Post-Cretaceous Stratigraphy of South Nigeria, 91.
Pre-Devonian Beds of the Mendips, 510.
Prosopon, Stratigraphical Position of, 82.
Prosopon in *Clypeus*-Grit, Cotteswold, 79.
Prosopon Richardsoni, H. Woodw., sp. nov., 79.
Pseudomorphous Pebbles of Pyrites, Crown Reef Mine, Witwatersrand, 187.
Ptychosphenoton Browni, H. G. Seeley, gen. et sp. nov., 433.
Pygocephalus, a primitive Schizopod Crustacean, Coal-measures, 400.
Pygocephalus (*Anthrapalæon*) *Parkeri*, H. Woodw., sp. nov., Coal-measures, Sparth, 406.

RADIUM in Rocks of Simplon Tunnel, 469.
Raised Beaches, Taltal (N. Chile), 48.
Rastall, R. H., Arrhenius' Theory of the Physical Causes of Vulcanicity, 173.
Recession of Niagara Falls, 440.
Reclus, Elisée, Volcanoes of the Earth, 236.

REE

Reed, F. R. Cowper, Coastal Features, Fornaght Strand, Co. Waterford, 17, 501, 549; Fauna of the Bokkeveld Beds, S. Africa, 34, 165, 222; Ashgillian Series, 140. Sedgwick Museum Notes: Crustacea, Girvan, 108; *Sladina catenuformis*, Haverfordwest, 208; A New Species of *Lichas*, 396; Base of Silurian, Haverfordwest, 535.

Relationship of 'Sparassodonta,' 531.

Reports and Proceedings: Dorset Natural History Field Club, 374; Geological Society, 46, 47, 91, 93, 138, 179, 180, 186, 188, 237, 284, 330, 331, 333, 374; Centenary of Geol. Soc., 522; Mineralogical Society, 94, 189, 286, 378; Palæontographical Society, 190; Zoological Society, 190.

Reynolds, S. H., Pre-Devonian Beds of the Mendips, 510; Silurian Inlier in Eastern Mendips, 188.

Rhinoptera prisca, A. S. Woodward, sp. nov., 195.

Richardson, L., Stratigraphical Position of *Prosopon*, 82; Inferior Oolite and Contiguous Deposits of Bath-Doulting District, 374; Inferior Oolite and Deposits of Rissington and Burford District, 375.

Rochdale, Lancashire, Arthropoda from Coal-measures, 405, 406, 539.

Rock-minerals, by Prof. J. P. Iddings, 563.

Rocks of Cape Colville Peninsula, New Zealand, 564.

Rocks of Northern Guernsey, 74.

Rocks of the "Beagle" Collection, 100.

Rosenbusch, H., Commemoration Volume of 70th Birthday, 363.

Rotiform Bryozoa of Chalk, 442.

Ruedemann, R., Cephalopoda, New York State Museum, 45.

SALINE Solutions and Ores, 525.

Sandstone Pipes in Carboniferous Limestone, Anglesey, 238.

Scandinavia, Lower Ordovician Rocks, 257, 295.

Scharff, R. F., European Animals: Geological History and Distribution, 366.

Schizopod Crustacean, *Pygocephalus*, Coal-measures, 400, 405, 407.

Schwarz, Ernst H. L., Tygerberg Anticline, 487.

Scotland, Geological Survey, New Maps, 1907, 283.

SOU

Scrivenor, J. B., Geologists' Report on the Federated Malay States, 565.

Sea-level, Deformation and Variation, 115.

Sedgwick Museum Notes: Crustacea from Girvan, 108; *Sladina catenuformis*, Haverfordwest, 208; A New Species of *Lichas*, 396; Silurian, Haverfordwest, 535.

Seeley, H. G., Eminent Living Geologists, 241; New Labyrinthodont, Karroo Beds, Cape Colony, 433.

Segerberg, C. O., & J. C. Moberg, Tremadocian Series, Sweden, 85.

Selbornian of Stonebarrow Cliff, Charmouth, 150.

"Sermons in Stones," 432.

Serviço Geologico e Mineralogico do Brazil, 528.

Seward, A. C., Fossil Plants, Egypt, 253; Fossil Plants from S. Africa, 481, 573; Permo-Carboniferous Plants, Vereeniging, South Africa, 573.

Shattuck, G. B., Maryland Geological Survey, 1906, 372.

Sheppard, T., Post-Glacial Lacustrine Deposit at Hornsea, 138.

Sheppard, T., & J. W. Stather, Glacial Gravels, Holderness, 468.

Sherborn, C. D., Index Generum et Specierum Animalium, 509.

Skeleton of *Diprotodon australis*, Owen, British Museum, 337.

Skull and part of Skeleton of *Goniopholis crassidens*, Wealden, Atherfield, I. of Wight, 46.

Silurian, Base of, near Haverfordwest, 535, 537.

Silurian Inlier in Eastern Mendips, 188.

Silurian Ophiurids, Australian Palæontologists on, 313.

Sladina catenuformis, F. R. C. Reed, gen. et sp. nov., Haverfordwest, 208.

Smith, J., Conodonts in Coal-measure Strata, 239.

Sollas, Professor W. J., & Alexander McKay, Rocks of Cape Colville, New Zealand, 564.

Solórzano, M. M., & B. Hobson, Plant-remains in Basalt, Mexico, 217.

Somabula Diamond-field, F. P. Mennell, 95.

South Africa, Fossil Plants from, 481, 573, 574.

South Africa, Pipe-Amygdaloids, 13.

South African Scenery, Geological Aspects of, 352.

South Australia, Palæontology of, 474.

South Wales Coalfield, Geology of the, 371, 514.

SOU

Southern Origin of Northern Zone in Savoy and Swiss Alps, 237.
Sparassodonta, Relationship of the, 531.
Spencer, J. W. W., Age of Niagara Falls, 285; Recession of Niagara Falls, 440.
Stanford's Geography: Australian Geology, 423.
Stather, J. W., Drift Deposits at Kirmington, 37, 471.
Stather, J. W., & T. Sheppard, Glacial Gravels, Holderness, 468.
Stewart, Prof. Charles, Obituary of, 526.
Stomatopora, Evolution of, 20.
Stone Implements associated with Fossil Mammalia, South Africa, 443.
Stone Implements of South Africa, 372.
Stonebarrow Cliff, Charmouth, The Selbornian of, 150.
Stopes, M. C., Relation of Concretionary Nodules of the Yarra to 'Coal-Balls,' 196; Flora of Inferior Oolite of Brora, Sutherland, 376.
Stracey, B., Charnwood Forest, North-West District, 420.
Strahan, A., Geology of South Wales Coalfield, 1907, 371.
Stratigraphical Note on Slade Beds, Haverfordwest, 537.
Stratigraphical Position of *Prosopon Richardsoni*, H. Woodw., sp. nov., 82.
Strontia Boulders in Trias, near Bristol, 471.
Structure of Glacier Ice, 529.
Submergence of British Islands, 335.
Summary of Progress of Geological Survey for 1905, 41.
Swansea Earthquake (June 27th, 1906), 377.
Swiss Geology, Bernese Oberland, 43.

THOMPSON, Beeby, Clay Beds by the Ouse, Bedford, 24.
Thomson, J. A., Inclusions in Volcanic Rocks, 490.
Titaniferous Volcanic Rocks, 157.
Toadstones of Derbyshire, 284.
Torquay, Hills and Valleys of, by A. J. Jukes-Browne, 562.
Tremadocian Series, Sweden, 85.
Trias compared with modern Deserts, 554.
Tygerberg Anticline, Professor E. H. L. Schwarz, 487.

UINTACRINUS in the London Basin, 288, 576.
Uitenhage Series, Cape Colony, Invertebrate Fauna of, 289.
Ussher, W. A. E., Geology of Devonshire, 362.

ZOO

VERTEBRATE Remains, Fayûm, Egypt, 97.
Volcanic Rocks, Inclusions in, 490.
Volcanic Rocks, Titaniferous, 157.
Volcanoes of Basutoland, 463.
Volcanoes of the Earth, Elisée Reclus, 236.
Volcanoes of Nevado de Toluca and Jorullo, Mexico, 5.
Vulcanicity, Arrhenius' Theory of Physical Causes of, 173.

WADE, Arthur, Chemical Composition of Igneous Rocks, 171.
Walcott, C. D., Appointed Secretary of the Smithsonian Institute, 287.
Walker, John Francis, Obituary of, 288, 380; his Collection of Brachiopoda given to National Museum, 576.
Ward, John, Longton, Staffs, Obituary of, 141.
Waterford Co., Ireland, Coast Features, 17, 501, 549.
West Australia, Geological Survey of, 44.
Whitaker, William, Eminent Living Geologists, 49.
White, H. J. O., Geology of Hungerford and Newbury, 568.
Wilkinson, S. B., Geology of Islay, 476.
Williams, G. J., Geological Age of Shales, Parys Mountain, Anglesey, 148.
Wills, L. J., Fossiliferous Keuper, Bromsgrove, 28.
Wilmore, A., Limestone Knolls, Craven, 36.
Wilson, J. H., Glacial History of Nantucket and Cape Cod, 137.
Woodward, A. S., Cretaceous Formation, Bahia, Brazil, and its Vertebrate Fossils, 93; New Dinosaur, Trias, Lossiemouth, Elgin, 93; Upper Cretaceous Fish-remains from Brazil, 193; A Reconstructed Skeleton of *Diprotodon australis*, Owen, British Museum, 337.
Woodward, Henry, *Prosopon* in *Clypeus* Grit, Cotteswold, 79; Two new species of *Eurypterus*, Coal-measures, Ilkeston, 277; *Pygocephalus*, a primitive Schizopod Crustacean, in Coal-measures, 490; Further Notes on Arthropoda in British Coal-measures, 539.
Woodward, H. B., History of the Geological Society, London, 385, 575.

XEROPHYTIC Character of Coal Plants, 330.

ZONES of Neolithic Times, 282.
Zones of the Chalk, 576.
Zoological Society, 190.

STEPHEN AUSTIN AND SONS, LTD., PRINTERS, HERTFORD.

No. 522. Decade V.—Vol. IV.—No. XII. Price 1s. 6d. net.

THE GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

LIBRARY OF THE UNIVERSITY OF WISCONSIN

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S, &c.

ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

DECEMBER, 1907.

CONTENTS.

I. ORIGINAL ARTICLES. *Page*

The Structure of Glacier Ice. By R. M. DEELEY, M.I.C.E., F.G.S. (Plates XXIII and XXIV.) 529

The Relationships of the 'Sparassodonta.' By Dr. W. D. MATTHEW, of the American Museum of Natural History, New York 531

Sedgwick Museum Notes: Base of Silurian, Haverfordwest. By F. R. COWPER REED, M.A., F.G.S..... 535

Stratigraphical Note. By T. C. CANTRILL, B.Sc. Lond..... 537

The Arthropoda of the British Coal-measures. By HENRY WOODWARD, LL.D., F.R.S., F.G.S. (With five Figures.) 539

Notes on the Coastal Features in Co. Waterford: Tramore Bay, etc. By F. R. COWPER REED, M.A., F.G.S. (With a Section in text.) 549

II. NOTICES OF MEMOIRS.

Desert Conditions and the Origin of the British Trias. By J. Lomas, A.R.C.S., F.G.S. (Concluded from p. 514.) 554

III. REVIEWS. *Page*

Professor J. P. Iddings: Rock Minerals 563

Professor Sollas: Rocks of Cape Colville, New Zealand..... 564

J. B. Scrivenor: Geological Report on Federated Malay States 565

Dr. Felix Oswald: Geological Map of Armenia..... 567

H. J. Osborne White: Geology around Hungerford and Newbury..... 568

IV. REPORTS AND PROCEEDINGS.

Geological Society of London— November 6th, 1907 573

V. CORRESPONDENCE.

Mr W. S. Gresley, F.G.S. 575

Mr. G. E. Dibley, F.G.S. 576

VI. OBITUARY.

Sir James Hector, K.C.M.G. 576

VII. MISCELLANEOUS.

The John Francis Walker Collection... 576

With this Number is presented an Extra Sheet, containing Index and Title for Decade V, Vol. IV, 1907.

LONDON: DULAU & CO., 37, SOHO SQUARE.

☞ **The Volume for 1906 of the GEOLOGICAL MAGAZINE is ready, price 20s. net. Cloth Cases for Binding may be had, price 1s. 6d. net.**

ROBERT F. DAMON, Weymouth,

Begs to call attention to his Varied Stock of

NATURAL HISTORY SPECIMENS

CONSISTING OF

Minerals, Fossil and Recent Shells,

ALSO

Fishes, Reptilia, Crustacea, Echinodermata,

etc., etc., Dry and in Spirit.

	£	*s.*	*d.*
400 species Foreign Fishes, Amphibia, Reptilia, and Crustacea in spirits from the Godeffroy Collection named and localized	25	0	0
Mounted Reptilia and Fishes and a large number of Insects and other recent specimens to be sold at a very low figure.			
1,600 species of British Fossils	100	0	0
Collection of Old Red Sandstone Fishes ... £15 to	100	0	0
55 species (170 specimens) Fishes, Crustacea, Mollusca, etc., from the Lower Carboniferous, Scotland ...	10	0	0
100 species British Carboniferous Fish Teeth, Mollusca, and Brachiopoda	4	4	0
Reptilian Remains, Mollusca, Crinoids, etc., from the Lias of Lyme Regis.			
200 species British Inferior Oolite Fossils	10	10	0
175 species (500 specimens) British Red Crag Fossils ...	8	17	6
87 species (347 specimens) Alpine Fossils	5	5	0
Vertebrate Remains from the Pliocene (Siwalik Hills), see photo.			
Rudistes, Hippurites, Requienia, from Dordogne.			
Cretaceous Fishes in large numbers, Cretaceous, Syria.			
Collection of Triassic Plants, Austria	2	15	0
123 species St. Cassian Fossils	6	6	0

Etc., etc., etc.

Lists of R. F. Damon's coloured casts of Rare Fossils, now numbering over 300 specimens, will be sent on application.

Any Museum acquiring such a grand series of Casts would possess much, not only to interest the student, but also to attract the general public.

A town about to establish a Museum would find that these specimens, when properly mounted and displayed in glass cases, with instructive labels to each, would form a substantial basis for a Public Museum at a very small cost.

IST OF BOOKS AND PAPERS ON SALE BY

LULAU & CO., 37 SOHO, SQUARE, LONDON, W.

BARRON (T.) & HUME (W. F.). Notes on the Geology of the Eastern Desert of Egypt. London, 1902. 8vo. Cloth. 2s. net.

BECK (R.). The Nature of Ore Deposits translated and revised by W. H. WEED. With 272 figures and a map. 2 vols. 8vo. Cloth. £1 13s.

BLAIR (A. A.). The Chemical Analysis of Iron. A complete account of all the best known methods for the Analysis of Iron, Steel, Pig Iron, Iron Ore, Limestone, etc. 6th edition. 8vo. Cloth. 18s.

BROUGH (B. H.). A treatise on Mine Surveying. 1906. 12th edition, revised. 8vo. Cloth. 7s. 6d.

BULLETIN DE LA SOCIÉTÉ MINÉRALOGIQUE DE FRANCE. From the commencement in 1878 to 1901, being vols. i-xxiv. 15 vols. half-calf, rest in parts. Meulan and Paris, 1878-1901. 8vo. £12.

BULMAN (H. F.) & REDMAYNE (R. A. S.). Colliery Working and Management. 1906. 2nd edition, revised and enlarged. 8vo. Illustrated. 18s.

COLLINGE (W. E.). Report on the Injurious Insects and other Animals observed in the Midland Counties during 1905. Fourth Report, illustrated. 1907. 8vo. Boards. 2s. 6d.

COOLEY (W. D.). Physical Geography; or, The Terraqueous Globe and its Phenomena. Illustrated with 125 wood engravings, frontispiece, and 12 maps. 8vo; 429 pages, with illustrations. Cloth. 12s. 6d. net.

COX (S. H.). Prospecting for Minerals. 4th edition. 1906. 8vo. Cloth. 5s.

DANFORD (C. G.). Notes on the Belemnites of the Speeton Clays. 1906. 8vo. Six plates. 1s. 6d.

GEIKIE A.). Text Book of Geology. 4th edition, revised and enlarged. 1903. 2 vols. 8vo. Cloth. £1 10s. net.

GEIKIE (J.). Structural and Field Geology for students of pure and applied science. 1905. 8vo. Cloth. Fifty-six plates and 146 illustrations in the text. 12s. 6d. net.

HATCH (F. H.). The Boulder Beds of Ventersdorp (Transvaal). 1904. Royal 8vo. Map and 2 diagrams. 2s. 6d.

HOFMANN (O.). The Hydrometallurgy of Silver, with special reference to Chloridizing Roasting of Silver Ores, and the Extraction of Silver by Hyposulphite and Cyanide Solutions. 1907. 8vo. Cloth. Illustrated. 17s.

HOLLAND (T. H.). The Mica Deposits of India. Calcutta, 1902. 4to. Nine plates. 4s.

HUBBARD (A. J. & G.). Neolithic Dew-ponds and Cattle-ways. Second edition. 1907. Royal 8vo. Cloth. Illustrated. 4s. 6d.

JOHNSON (J. P.). Stone Implements of South Africa. 1907. 8vo. Illustrated. 7s. 6d.

JOHNSON (J. C. F.). Getting Gold: A practical treatise for Prospectors, Miners, and Students. 3rd edition. 1904. 8vo. Cloth. Illustrated. 3s. 6d.

KERR (GEORGE L.). Practical Coal Mining: A Manual for Managers, Under-Managers, Colliery Engineers, and others. Illustrated. 3rd edition, thoroughly revised. Crown 8vo. 12s. 6d.

LAPWORTH, WATTS, & HARRISON. Sketch of the Geology of the Birmingham District. 1898. 8vo. Three plates. 2s.

LOVEGROVE (H. J.). Attrition Tests of Road-making Stones, with Petrological descriptions by J. S. FLETT and J. ALLEN HOW. 1906. 4to. 5s.

PEACH (B. N.), HORNE (J.), GUNN (the late W.), CLOUGH (C. T.), & HINXMAN (L. W.). The Geological Structure of the North-West Highlands of Scotland. With Petrological Chapters and Notes by J. J. H. TEALL. Edited by Sir ARCHIBALD GEIKIE. Glasgow, 1907. 8vo. Cloth. 52 plates and map. 10s. 6d.

PENFIELD (S. L.). Tables of Minerals, including the Use of Minerals and Statistics of the Domestic Production. New York. 2nd edition. Demy 8vo. 1907. 4s. 6d. net.

PETERS (E. D.). The Principles of Copper Smelting. 1907. 8vo. Cloth. £1 1s.

RIES (H.). Clays: their occurrence. 1906. 8vo. Cloth. £1 15s. net.

——— Economic Geology of the United States. 1906. 8vo. Cloth. 11s.

SCHARFF (DR.). European Animals: their Geological History and Geographical Distribution. 1907. 8vo. 7s. 6d. net.

SCHNABEL (CARL DR.). Handbook of Metallurgy. Translated by H. LOUIS. 1905–7. 2 vols. 8vo. Cloth. £2 6s.

TINNEY (W. H.). Gold Mining Machinery: its Selection, Arrangement, and Installation. 1906. 8vo. Cloth. 12s. 6d. net.

TONGE (J.). Principles and Practice of Coal Mining. 1907. Crown 8vo. Cloth. Illustrated. 5s. net.

VAN HISE & BAYLEY. The Marquette Iron-bearing District of Michigan. Washington, 1897. 4to. Thirty-five plates, some coloured. With folio atlas. Cloth. £2 2s.

WALKER (S. F.). Electricity in Mining. 1907. 8vo. Cloth. 9s.

WOODWARD (H. & H. B.). Table of British Strata. Net, 5s.; folded in book-form, net, 6s.; mounted on linen, with rollers, and varnished, net, 16s.

ZEILLER (R.). Description de la Flore Fossile du Bassin Houiller de Valenciennes. Paris, 1886–8. 4to. Text and atlas. £3 8s.

NOW READY.

JUKES-BROWNE (A. J.). The Hills and Valleys of Torquay. A study in Valley Development and an explanation of Local Scenery. Torquay. Crown 8vo. Cloth. 7 plates, 6 maps, and diagrams in the text. 3s. 6d. net.

NOW READY. *Net £1 5s.*

A GEOLOGICAL MAP OF ARMENIA

And its Border-Ranges, with Indications of Minerals and Mineral Springs.

Drawn and Hand-coloured by FELIX OSWALD, D.Sc., F.G.S.

With explanatory notes. 16 pp. 8vo.

The descriptive text is comprised in the author's "Treatise on the Geology of Armenia." In addition to his own geological observations between Trebizond and Lake Van, he has made use of all available material in the works of Abich, Ainsworth, Batowich, Fournier, Frech, Hamilton, Koch, Loftus, Möller, Pohlig, Radde, Simonovich, Tchihatcheff, Tsulukidse, Wagner, and 140 other investigators mentioned in the Bibliography of the author's "Treatise." Scale: 16 miles = 1 inch (1 : 1,013,760). Heights in English feet. Mountain ranges are represented by thick lines, which also indicate for the most part the main axes of mountain-folding.

DULAU & CO.

CHANGE OF ADDRESS.

All communications for this Magazine should be addressed—

TO THE EDITOR,

13, Arundel Gardens, Notting Hill, London, W.

Books and Specimens to be addressed to the Editor as usual, care of

MESSRS. DULAU & CO., 37, SOHO SQUARE, LONDON, W.

STEPHEN AUSTIN AND SONS, LTD., PRINTERS, HERTFORD.